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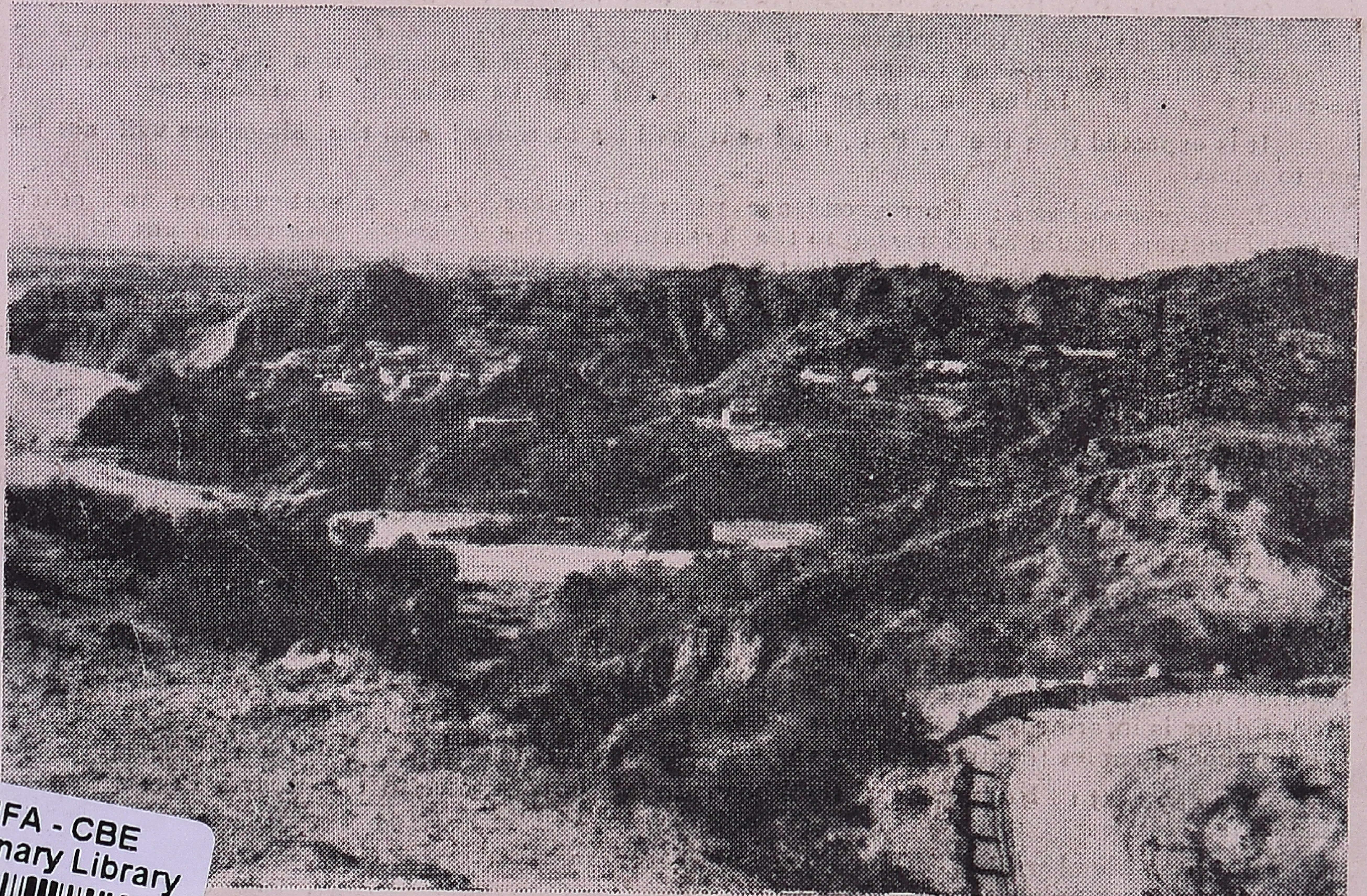
The Madras Forest College Magazine

"Soil Conservation and Land Management"



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The Madras Forest College Magazine.

A Quarterly Journal of Forestry, Shikar & Travel.

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Madras Forest College Magazine.

Published Quarterly

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N. B :- Contributors are requested to send in their contributions written legibly in ink on one side of the paper only or in type-script.

EDITORIAL.

It is with very great pleasure and satisfaction the special number on "*Soil Conservation and Land M* ich will help in some measure to focus the attention o ters and others on this very important problem. We ho ject namely, to invoke thoughts in the young minds, as to how best this problem is to be tackled will be achieved in no small measure through this issue.

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The problem of soil erosion in India had been taken up towards the close of the last century, and has had a marked effect on both agricultural and forestry practices. Now, with the formation of Soil Conservation Boards in many States we see yet another forward step in this field, and from what we have been seeing in some of the States we are assured that this country is tackling the problem in a very systematic manner.

Our students have seen on tours the success achieved at Bidar, Hyderabad State, in soil Conservation *cum* afforestation works, and also the rapid progress the Madras State is making in the Nilgiris by bringing the eroded hill sides under sound principles of soil conservation and land management. These hills which once bore a protective soil cover had been stripped of the forest and badly managed under potato cultivation which took its impetus from inflated prices during the war years. The results achieved in the Nilgiris now bear testimony to the ryots who take very nicely to the re-orientation of their agricultural practices. It is now well within reason to expect higher yields from their agricultural crops and more forests clothing the zones which are now no longer suitable for agriculture. Thus we see how much the need is for both the Agriculturist and the Forester to fight the common foe - *soil erosion.*

We are very grateful to all those officers, who, from various parts of this Union, have so earnestly responded to our appeal in order to bring out such an issue pregnant with valuable information on the problems of soil erosion which confront us today and especially, we are indeed much obliged to Shri M. Bhaktavatsalam, the Hon'ble Minister for Agriculture and Forests, Madras State, for the lively interest he has evinced in this College, and for his article which is so pertinent.

Outgoing Students: Again we have come to the close of another academic year and would take this opportunity in wishing the outgoing Rangers and Foresters God-speed and success in the career they are embarking upon, and trust that they will endeavour to give their best in their respective forest services and thus reflect credit to this Institution, their Alma Mater.

Incoming Students: To the new students we extend a very hearty welcome. We must also congratulate them of having so wisely chosen a career in which they could not only live in close contact with nature but enjoy the benefits which many have been deprived of and would give much to get what forest officers enjoy in an outdoor life.

Constitution of the Central Soil Conservation Board and its Programme of Work.

By D. C. Kaith B. Sc., (Edin.)

(Director of Soil Conservation, Central Soil Conservation Board Ministry of Food & Agriculture)

Man has destroyed the forests, has cultivated fields and raised crops on steep slopes for short periods until rains have eroded away the soil, has allowed his cattle to graze and browse until the vegetation has been destroyed and rocks have been laid bare. Over many parts of India such as Assam hills, Chota Nagpur plateau, Nilgiris, Siwaliks, Himalayas, the balance of nature has been up set and nature is taking a terrible revenge. Floods and Famines have become common.

Soil erosion has been described as a creeping death. Erosion affects both animals and men. Due to erosion, crop yields decline, and pastures deteriorate. Neither the man himself nor his animals get enough to eat. These conditions prevail in many parts of India today.

Steps for the Control of erosion and soil conservation have been taken for some years past in some parts of India such as Bombay where *bunding* has been done on a large scale in the Deccan, Punjab where torrent training and afforestation works are in progess in the Siwaliks, Damodar Valley authority where afforestation, trenching etc. are being done. But there has been no country-wide effort to take up the soil conservation work. Realising the importance of this work the Planning Commission made provision of funds during the first 5 year plan and under its recommendations the Central Govt. has set up a Central Soil Conservation Board in the Ministry of Food and Agriculture with head quarters at New Delhi. The composition of the Board is as follows :—

Chairman. Union Minister of Agriculture.

Members. (i) Secretary, Ministry of Food & Agriculture (or his nominee)

(ii) Agricultural Commissioner, I. C. A. R.

(iii) Inspector General of Forests

(iv) Member (waterways irrigation and navigation) of the Central Water and Power Commission.

Secretary: An Officer of the Ministry of Food & Agriculture. The Board will be provided with necessary funds and with adequate technical and other staff for carrying out its functions. The functions of the Board will be as under :—

(i) to organise, coordinate and initiate research in soil Conservation on various types of lands put to different kinds of land use such as agriculture, forestry, grazing etc.

(ii) to assist States and River Valley projects ;

(a) in drawing up their schemes

(b) in the enactment of legislation required for the purpose ; and

(c) by tendering such technical advice as may be required for time to time.

(iii) to act as a clearing house of information on soil conservation and as store house of experience gained in various parts of the country. It will organise publicity and arouse public consciousness against misuse of land.

(iv) to arrange for the training of technical personnel of the upper as well as the lower grades required to implement soil conservation schemes.

(v) to provide such assistance as may be required in carrying out reconnaissance or detailed surveys in accordance with standards laid down for the sake of uniformity through out the country.

(vi) to recommend financial assistance for schemes of states and river Valley projects on an approved basis. This would include research, demonstration and extension;

(vii) to coordinate inter state soil conservation projects and

(viii) to undertake such cognate measures as are germane and relevant to the pursuance of the aims and objects of the Board.

The Central Board has the following technical staff at the Headquarters.

(1) Director of Soil Conservation (Forest)
(2) Director of Soil Conservation (Agriculture)
(3) Director of Soil Conservation (Engineering)

The Under Secretary of the Ministry of Food & Agriculture acts as Secretary of the Board.

Various states have sent schemes of Soil Conservation for financial aid from the Board and these are under consideration of the Board. The Board is planning to set up Soil Conservation Research cum training centres at the following places.

(1)	Sholapur.	Bombay (black soils)
(2)	Sahib Nagar	Hyderabad (Murram)
(3)	Hazaribagh	Bihar.

Damodar Valley River Valley problems.

(4)	Alluvial Soils	Datia, Vindhya Pradesh
(5)	Jodhpur	Rajasthan desert
(6)	Siwaliks of the Punjab	Place to be decided
(7)	Himalayas	do.

These centres will not only conduct research in conservation problems, but will be used for training officers also sent by the states and engage in extension work.

Work at Jodhpur desert research station is already in full swing. Trials of different species of trees, shrubs and grasses suitable for desert afforestation are going on. Operations to create forest belt on the frontier to check Rajasthan desert have been started.

Various states have constituted Soil Conservation Boards on the lines of the Central Soil Conservation Board to frame schemes of Soil Conservation.

Soil Conservation in Madras State.

By **Shri M. Bhaktavatsalam**

(Minister for Agriculture, Madras)

Introduction: Of the total area of 1,27,000 sq. miles of the composite State, about 17·4% only is under forest cover as against the prescribed 25% that should normally be so for the proper protection and well being of the country. The remaining area is either sown or left fallow as uncultivable or cultivable waste or utilised for other purposes. The problem of soil erosion as it applies to the cultivated lands covers an extent of about 31·82 million acres of sown area *i. e.* about 39% of the total area. Of this the area under irrigation is estimated to be only about 9·6 million acres. Irrigated lands are generally terraced in a level fashion and bunded so as to ensure effective utilisation and are therefore better protected against soil erosion. The area under dry cultivation *i. e.* the lands that depend upon the vagaries of the monsoon and the lands on which agriculture is a gamble more or less, extends to nearly 71·5% of the total area. These lands are generally exposed to the vagaries of monsoons and ravages of winds. And soil erosion is comparatively more intense on these lands which are progressively getting impoverished and are liable to be rendered barren in the long run.

Erosion of soil: 2. When it rains in sharp showers, the soil particles are dispersed and carried down by the running water. Similarly, when the area experiences a strong wind during the hot and dry periods preceding the monsoon, the fine top soil is blown away with the wind and deposited in drifts or dunes, thus depriving the land of the fertile top layers at some places and engulfing the cultivated lands which are thrown out of cultivation at other places. These soil movements are termed generally as water and wind erosion. Continued soil erosion results in progressive deterioration of the productive soil layers and with it the fertility that is needed for better agriculture also gradually diminishes. It is the top layer of soil that supplies the required plant food which forms the very basis of all agriculture by which food is made available to the Nation and animals, and which can, therefore, be called the life-blood for the well-being of

the Nation. If this soil becomes badly denuded, agriculture will be rendered impossible and the Nation deprived of the benefits that are derived from the soil. Erosion is, therefore, a 'NATIONAL MENACE' and requires the highest priority in any nation building plan for improving agricultural production.

Steps undertaken by the State: 3. Soil erosion in Madras State is becoming more and more serious and large tracts of badly eroded lands are becoming commonly visible under the areas that have been left uncultivated. The severity of the problem of soil erosion is, therefore, increasing progressively in all vulnerable areas.

4. Realising the adverse effects of indiscriminate deforestation of the Punjab Siwalik - range of hills, the work of soil conservation was pioneered in that State somewhere during 1900. The Bombay State took to large scale bunding work and intensified researches on soil conservation methods during 1940. Madras followed suit in attempting to solve this serious problem of soil erosion on cultivated lands.

5. The first realisation of soil erosion dangers as a serious impediment to sustained agricultural development came as an off-shoot of the research work on dry farming practices conducted during 1934 to 1943 at the Agricultural Research Station, Hagari, at the instance of the I. C. A. R. and so researches on soil conservation work were also carried out in an interlinked manner, at this Station. The results of these experiments and the recommendations thereof were tried at Hagari on a limited scale under the dry-farming development scheme. As the result of these trials, the Department commenced advocating large scale contour bunding to prevent soil erosion, conserve moisture and thereby improve the lands permanently particularly in the dry farming areas with a precarious rainfall.

6. To assess the magnitude of the problem of soil erosion on the Nilgiris and the effect of soil conservation measures, researches on field scale were conducted on run off plots at the Agricultural Research Station at Nanjanad from 1942 onwards and the results of these researches reveal most convincingly that maximum soil erosion occurred on land left as clean fallows and the minimum on the land

covered by indigenous grasses. It also provided conclusive proof that the method of cultivating across the slope is more advantageous than the method of cultivation along the slope normally followed by the ryots and that soil erosion was increasingly intense on steeper slopes of land.

7. Considering the severe losses caused by soil erosion in the State it was decided to organise large-scale extension work on soil conservation methods and for this purpose a few selected personnel were specially trained in soil conservation at the Soil Conservation Training Institute, Sholapur, in Bombay State where post-graduate short term courses are regularly conducted.

8. On the recommendation of the Experts of the Government of India, a State Soil Conservation-Board was also constituted in 1951 with a view to initiate and co-ordinate schemes for soil conservation in the State with the Minister for Agriculture as the Chairman.

9. A District Soil Conservation Board for the Nilgiris with the District Collector as its President, and a few selected officials and non-officials as its members, is also functioning from the year 1947. The function of this Board is to discuss problems relating to Soil Conservation in the Nilgiris and render all help and assistance as well as to initiate and co-ordinate Soil Conservation schemes for the district.

Madras Act XXII of 1949. 10. With a view to empower the state Government to initiate and undertake soil conservation works in private lands, "The Madras Land Improvement Schemes (Contour Bunding & Contour Trenching) Act of 1949 was enacted. The Act empowers the State Government to carry out soil conservation measures in a notified area and recover the cost thereof in full or part in easy instalments from the beneficiaries. This Act was first extended to Bellary and Anantapur districts of the composite State. It is now made applicable to the Nilgiris District and portions of Coimbatore and Malabar Districts.

Contour bunding work in Rayalaseema: 11. The first major soil conservation scheme undertaken by the Madras State in its composite structure was in 1949. Three watersheds extending to about 6,049

acres, 6,910 acres and 6,845 acres at Hagari, Alur in Bellary and Guntakal in Anantapur respectively were selected, surveyed and scheme proposals were worked out.

12. The area actually covered during the first stage was limited to 4,800 acres in these centres and appropriate soil conservation works like contour bunding, construction of waste weirs, gully plugging, contour trenching and afforestation, sowing of grasses on bunds etc., have been carried out by the Agricultural Department. The agronomical practices for promoting soil conservation were also simultaneously advocated by the extension staff in these selected areas.

Soil conservation work in the Nilgiris : 13. In view of the visibly increasing soil erosion menace and the rapid extension of land use for exploitative cultivation of potato, an important food crop of the district, the scheme for soil conservation was extended to this hilly region for execution under the provisions of the Madras Act XXII of 1949. As a pilot scheme, an area of about 300 acres forming a sub-catchment of Ketty Valley in Coonoor taluk was selected and out of this an area of 89 acres have been taken up initially. Suitable soil conservation works like bench terracing, contour trenching and afforestation, diversion channels, stream protection, gully plugging, and establishment of grasses were carried out over these 89 acres. The work in the remaining area has also been taken up and is in progress.

14. Further schemes are on hand to set up demonstration plots on a representative basis in Ootacamund and Kotagiri Sub-circles and Gudalur taluks of this district to bring home to the farmers of these areas the necessity and advantages of such protective measures.

15. To promote effective propaganda of proper soil conservation measures, the village officers and Revenue Inspectors of Nilgiris District were given special short term training and courses of instruction in soil conservation technique.

16 Sanction has also been accorded for granting of long-term loans at the rate of Rs. 300/- per acre subject to the maximum of Rs. 1,500 per head for carrying out protective works as per directions of the soil conservation staff in the Nilgiris District to stimulate the cultivators' enthusiasm and interest in this direction.

Soil Conservation as a Famine Relief work: 17. It is not merely the continued seasonal failure that results in famine conditions, but the shallowness of the soil has a great bearing in prolonging famine. If the soil is shallow, adequate moisture so very essential for the proper growth of plants cannot be stored and what little rainfall may be precipitated on these lands will go largely to waste as run-off. Conservation measures with contour bunding as the main feature not only improve the physical character of the soil layers but help absorption of a greater part of rainfall which, while percolating through subsoil will add to the replenishment of underground water. The general water table will thus be increased in due course and facilities for irrigation improved. Soil Conservation works are therefore long term measures that will go a long way to prevent recurrence of famines. Moreover, the main feature of contour bunding being simple earthwork, requires no skilled labour for execution and the local rural population can be engaged without having to import workers from other centres. Soil conservation work with contour bunding as its main feature was therefore taken up as a famine relief measure in Chittoor District of the composite State and Coimbatore District of the residuary State. The work in Chittoor District contemplated execution in about 3,800 acres in Chittoor taluk and about 4,000 acres in Vayalpad taluk and the major part of the work was completed before separation with the local rural population who had no agricultural field engagements.

18. The scheme in Coimbatore District contemplated tackling about 6,000 acres in Mulanur of Dharapuram taluk and so far 6,752 acres have been contour bunded. Construction of waste weirs, gully plugging, raising of wind belts etc, are in progress. That the soil conservation works can be successfully taken up as a famine relief measure by engaging the distressed agricultural labourers in affected areas has been amply demonstrated by both these famine area works.

Soil Conservation measures in Forest area: 19. There is not much of erosion inside the Reserved Forests which are directly managed by Government according to definite working plan which provides for systematic regeneration side by side with exploitation. However, the village forests which were left to be managed by Panchayats were

indiscriminately over-exploited with the result that they have become degenerated and vulnerable to erosion. To set matters right the Panchayat forests with an extent of 3,390 sq. miles have been taken under the control of the Forest Department.

20. Under the Five Year Plan a soil conservation branch under the State Silviculturist was opened with the object of dealing with soil erosion in the Nilgiris District and the adjoining Attapady Valley of Malabar and Coimbatore Districts. To start with, measures required to check erosion in lands of different gradients were taken up. Contour trenching and bench terracing experiments were carried out in Ketty in a 15 acre plot. The work started in Ketty has been completed and the area planted with *bluegum* and *wattle*. This plot has now yielded satisfactory results. Further more, afforestation work has been undertaken over an area of 10,000 acres (70 centres of 150 acres each) of barren reserved forest lands in dry districts. Apart from restocking these fuel forests, the work will effectively arrest the development of sheet and gully erosion in these exposed sites.

All India Problem: 21. Soil erosion is not only a problem of the Madras State but for the whole of India in general. The nature and intensity of soil erosion under the present method of cultivation is increasing year after year and a co-ordinated effort against such menace is needed urgently on a countrywide scale.

22. A Soil Conservation Society of India was formed in the year 1952 so as to focus the attention of the people to the need for conservation of soil and to promote an integrated approach to the problem by all States as part of the National Planning Programme.

23. A Central Soil Conservation Board with the Union Minister for Agriculture as Chairman and a Secretary and four members to assist the Board has also been formed recently. The functions of this Board are centred over the main object of conservation of the soil, protection of lands, reservoirs and projects against erosion menace and promotion of better agriculture.

An appeal: 24. The problem of soil erosion does not commence and end at or near the field boundaries, or at the various village

boundaries. It is the problem in all watersheds all over the State and country. It needs co-ordinated effort and better appreciation and co-operation of the ryots who are the real sufferers ultimately. Agriculturists and farmers should realise more fully the need to co-operate with the Government in preventing this progressive loss and help protection of the lands permanently against erosion for the promotion of sustained agriculture. They should also come forward to make the best use of the technical assistance provided for this purpose and themselves, take necessary steps to improve their lands. They should also protect the forests and the trees, and plant more trees and shrubs anywhere and everywhere so that the future generation may prosper.

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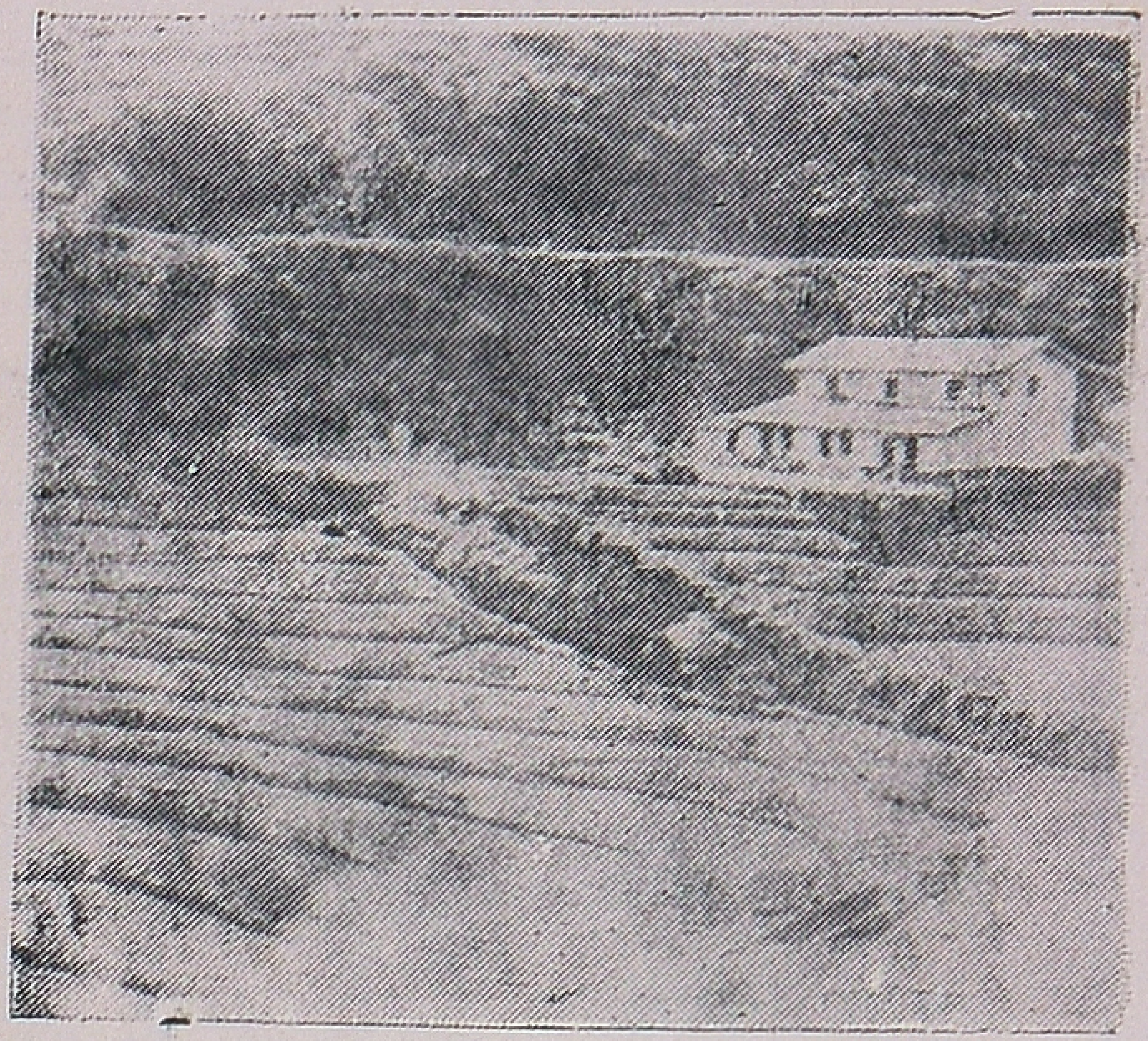
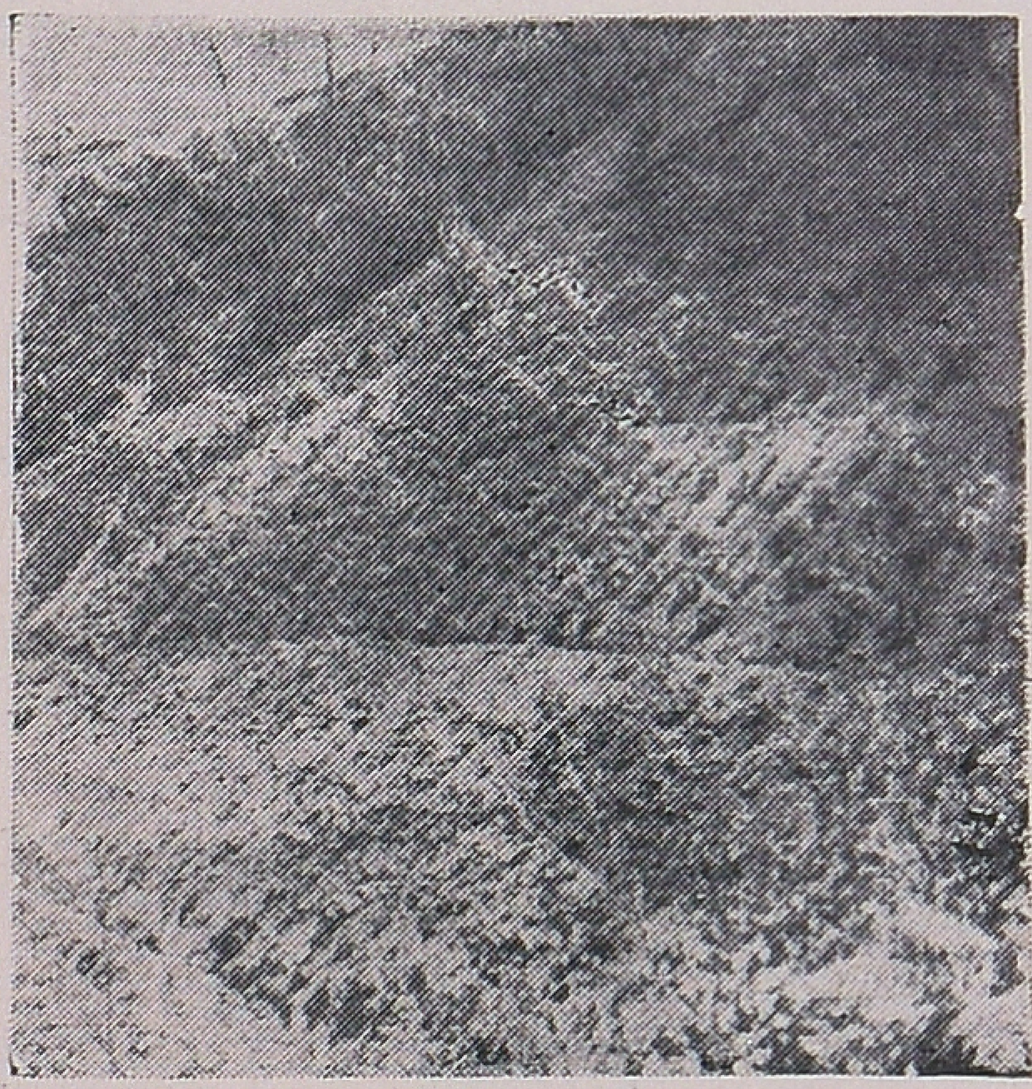
Sheet Erosion



Work in the Nilgiris Bench Terracing at Ketti

Initial Stages of Gully Erosion



Poor Growth of Crop on Unterraced Area

Contour Bunding as a Famine Relief Measure in Mulanur Firka of Dharapuram Taluk

Good & Uniform Growth of Crop on Terraced Area

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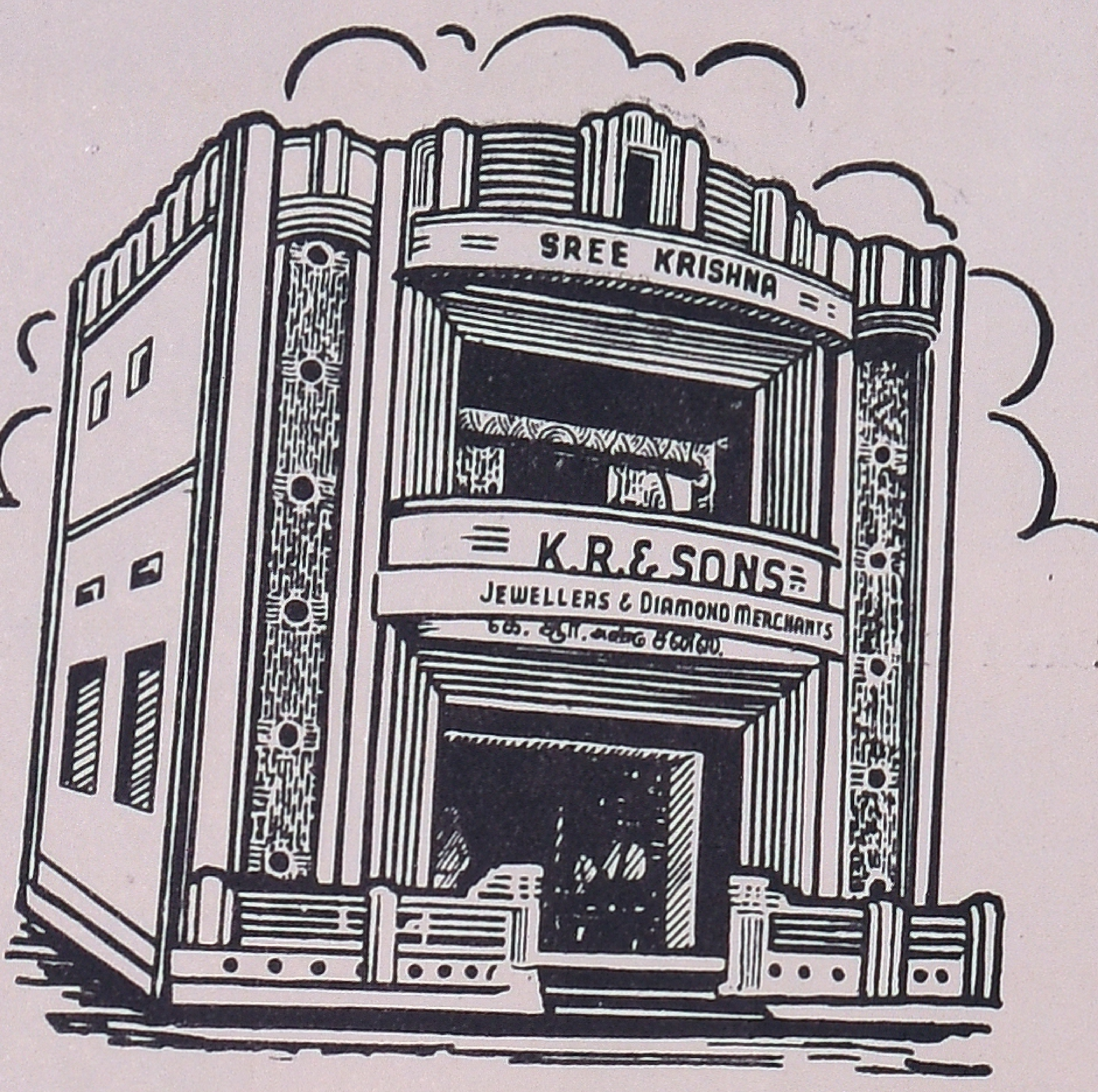

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Afforestation in the Indian (Rajasthan) Desert.

By Gurdial Singh Lamba,

Chief Research Officer,

Desert Afforestation Research Station, Jodhpur.

Summary: The Rajasthan Desert with a total area of about 80,000 sq. miles mainly consisting of wind-blown sands is either unproductive or partially productive and there are considerable sand movements. This desert has attracted considerable attention from technical experts and economists for some time past. Fears have been expressed that the desert is spreading at an alarming pace. At the symposium on the Rajasthan Desert held at New Delhi in March, 1952, it has generally been agreed that accentuation of the desert conditions is due to the peculiar type of wind erosion set up by unwise use of natural resources by man. The Desert, however, can be controlled and even reclaimed by suitable desert control measures. One of the most important desert control measures is afforestation. The Government of India has recently set up a Desert Afforestation Research Station at Jodhpur and this note discusses the peculiar physical, geological and climatic conditions prevailing in the desert area and desert afforestation problems which the station has come across during its experimental afforestation work and methods of afforestation being tried.

Introduction: Since the attainment of independence of India in 1947 and the integration of several small princely states into the present state of Rajasthan, the Rajasthan desert where the conditions are known to be deteriorating has drawn considerable attention. A large area of this desert is either unproductive or only partially productive. There is a great shortage of food, fodder and fuel. Fears have been expressed that the desert was spreading and reference was made to this by the Planning Commission in the First Five Year Plan. In the symposium on the Rajasthan Desert held at New Delhi by the National Institute of Sciences of India in March, 1952, although there was some divergence of opinion with regard to the actual extension of the desert, there was unanimity with regard to the

deterioration of conditions of life within the desert area. Although the prime causes of the formation of this desert are climatic and geological and therefore beyond man's control but its accentuation since 1000 A. D. can be definitely attributed to the action of man and his unwise interference with nature. Inspite of unfavourable climatic conditions this desert is not a desolate and leafless place. An examination of areas where there has been little interference from man and his domestic animals shows that these sandy uplands bear vegetation far greater than one would expect. But where man has settled, uncontrolled lopping, excessive and uncontrolled grazing and cultivation of marginal and sub-marginal lands has resulted in the removal of desert scrub and transformation of stable sand dunes into shifting sands which in addition to bringing about local ruination tend to spread north-wards and east-wards with the strong winds prevailing in the area. During summer, sandstorms and duststorms are common and dust is carried as far as the Himalayan hills. Thus man's unwise exploitation of land resources has set up a peculiar type of soil erosion and desert formation. If vegetation encouraged by giving protection from depredations of man and his domestic animal, the desert can be controlled and even rehabilitated.

The Government of India has set up a Desert Afforestation Research Station at Jodhpur under the administrative control of the President, Forest Research Institute & Colleges, Dehra Dun, in October, 1952. This Station is carrying out experimental afforestation work with a view to developing a technique for the fixation of shifting sands by means of vegetation. The following notes give a description of the area and record facts and experience of afforestation experiments carried out so far by this Research Station.

2. Situation and Area: The Rajasthan desert is situated in the north west of India, between 24° and 30° north latitude. It covers a large part of western Rajasthan, Southern Punjab and Patiala and East Punjab States Union. It extends over an average width of about 200 miles from the Aravalies to the basin of the Indus and a length of 400 miles from the southern Punjab plains to the Rann of Cutch. The area is mostly unproductive with precarious rainfall and a

very low water-table. It however improves from a complete desert in the west and northwest to comparatively fertile land to the south-east and east.

3. Physiography, Geology and Soil. The chief physical feature of Rajasthan desert is that it is a vast sandy plain. It is, however, not one flat level waste of sand but there are numerous isolated hills or groups of rocky hillocks or plateaux in various parts of it. The desert can be divided into several belts running NNE—SSW. The westernmost belt of the Great Desert is completely covered by sand dunes and runs from Great Rann along Pakistan border to the Punjab. The next belt is the dune-free rocky Barmer-Jaisalmer-Bikaner tract where the Jurassic to Eocene marine formations are exposed. On the eastern border of this rocky area is the little Desert which starting from the Great Rann meets the Great Desert again north of Bikaner. Then comes the basin of the Luni with the salt lakes of Didwana, Sambhar and others. The sub-montane zone of the Aravalies forms the eastern border of the Rajasthan desert. Between the sub-montane tract below the Aravalies and the desert, there is a longish belt of good sandy or light soil. It becomes more barren and sandy as one proceeds to the north and west. The bulk of the alluvial country in the delta of the Luni and the Barmer - Jaisalmer - Bikaner tract is free from dunes. Due to the action of the prevailing winds, sand has been heaped in a series of ridges or dunes of various shapes and sizes. There are three types of sand dunes: (1) Longitudinal dunes (2) barchans and (3) transverse dunes. The longitudinal dunes are in the form of long, straight ridges often attaining the magnitude of hills 200 to 500 feet in height and run NNE-SSW *i. e.* parallel to the prevailing wind direction and occur in the south and west. Barchans with the concave side facing the wind are found in the interior and transverse dunes aligned across the wind direction to the east and north. The windward slope is usually long, gentle and undulating while the leeward slope is abrupt and steep. The desert terminates in the south west in a broad depression of the Great Rann of Cutch.

Systematic soil studies in these areas have not yet been carried out. As a whole the tract is sandy but the soil improves in fertility from west and north west to east and north east. The area lying at the

foot of the Aravalies range, contains fertile land. Many parts are saline or alkaline with efflorescence and in the Rann of Cutch, salt flats, salt and mud are also met with.

4. **Climate.** The Rajasthan Desert is a hot desert, *i. e.* a region in which high temperatures and small rainfall cause the evaporation to exceed the precipitation considerably. As a consequence there is insufficient moisture for vegetation to thrive. The climate is characterised by excessive drought with scanty and irregular rainfall and extremes of temperature and seasonal variation. The aridity increases as one proceeds to the west and north-west from the Aravalies.

About 90% rainfall occurs in two to six showers during the monsoon period from June to September and 5% during the cold weather period from December to February. The winter is quite cold and at many places the temperature falls below freezing point and frost occurs. On the other hand, heat during summer is intense. The change of temperature from day to night is sudden, very large and trying.

In the hot season and during the monsoon, winds are generally from south-west and west but during the cold weather period north westerly and northerly winds are more frequent than those from other directions. Hot and dust raising winds are experienced during summer and they are strongest during the month of June. Dust storms are frequent especially in the arid region in the west. The maximum velocity of wind is about 85 m. p. h. The relative humidity of the atmosphere is low. Heavy dew falls in December and January.

5 **Water Supply.** Water is far below the surface and naturally scarce in this region. The water table varies between 30 to 50 feet near the banks of the Luni river and its tributaries in the sub-montane tract at the foot of the Aravalies while further to the north and west it varies from 100 to 500 feet.

6. **Indigenous Vegetation.** The Rajasthan desert forms the eastern end of the great desert region of the world extending from the Atlantic coast of Africa to Sahara, part of Arabia, South Persia and Baluchistan. Due to hostile environmental conditions, only such

plants as possess special adaptations to enable them to obtain water and to retain it when obtained can establish themselves. The flora mainly consists of a kind of scrub comprising shrubs and perennial herbs. The number of trees is small and they are stunted and generally provided with thorns or prickles to protect them against animals and vary in height from 15 to 35 feet. The trees and shrubs tend to be collected in clumps leaving plenty of vacant spaces between the clumps. In depressions between the dunes, *Prosopis spicigera* is found. It grows to about 35 feet in height and 4 ft. to 5 ft. in girth. *Acacia senegal* is common but does not grow much over 20 feet in height. *Tecoma undulata* grows to the same height as *Prosopis spicigera. Salvadora oleoides, Balsamodendron mukul* and *Zizyphus* grow into small trees and are quite common. Of the shrubs, *Calligonum polygonoides, Capparis aphylla. Zizyphus rotundifolia, Leptadenia spartium, Calotropis procera* and *Euphorbia neriifolia* are the commonest. There are at least a dozen fairly common spp. of grasses.

7. Factors Inimical to Afforestation. Edaphic factors :— Soil on the rocky hills and plateau is very shallow and poor. On steep hill sides, there is no soil worth the name. Owing to the denudation of vegetation, the valuable top soils in most of the area has been washed away or rather blown away leaving behind unstable sand, gravel or loose stones which are not very favourable for the establishment of tree growth. In places, there are thick beds of calcareous *tufa* or *kankar* pan below the sand which cannot be easily penetrated by roots of trees. Saline and alkaline soils, with unfavourable physical conditions and high ph value are also common.

Climatic factors. (a) Drought and hot winds-Not only the rainfall is low but it is erratic and irregular in distribution. The bulk of the rain falls in July and August in a few sudden showers and is followed by long periods of drought which cause considerable mortality amongst seedlings. Winter rains are unreliable. The hot weather being intensely dry desiccates the soil and countless seedlings are lost.

(b) Frost : Severe winter and early spring frosts are of frequent occurrence and cause considerable damage specially to seedlings. In years of exceptional frost, entire plantations are likely to be wiped out.

(c) Storms: Severe storms occur during summer and may cause considerable damage to trees and also desiccation of the soil.

Biotic factors: (a) Grazing: The bulk of the population of the desert being pastoral, there are vast herds, of cattle, camel, sheep and goats. Damage by grazing in some places is so heavy that nothing grows to more than a few feet from the ground level and even tree species develop bushy character, Extensive goat and camel grazing are a serious hindrance to the establishment of young plantations.

(b) Man: Lopping of branches and leaves of *Prosopis spicigera* and other species for fodder and fencing are common.

(c) Wild animals: The desert is full of rats. They eat cotyledons and even leaves and cause serious trouble in afforestation work. Rabbits and porcupines also cause some damage.

(d) Termites: White ants are a menace to plantations in some parts.

(8) Technique of Afforestation of Arid Areas: Besides involving expenditure of large sums of money afforestation work in the arid areas required considerable skill on the part of the forester.

Different conditions of soil and rainfall need different treatment. The following notes discuss some of the problems encountered in our experimental afforestation in this area.

Protection: For attaining success in afforestation work and safeguarding the stabilisation of sand dunes, closure of the area to man and to grazing by animals is absolutely essential. For this purpose effective fencing is essential. Several kinds of fencing are being tried. Trenches 5′ x 3′ to 6′ x 4′ with dug up earth piled along the inner edge and thickly sown with seed of babul (*Acacia arabica*), mesquite (*Prosopis juliflora*) and aloe (*Agave* spp) are also being tried.

Conservation of Soil moisture: The success of afforestation in arid areas mainly depends on conservation of soil moisture. Steps must be taken to conserve all available moisture and prevent surface run off. Interrupted contour trenches have proved very useful in holding up

rain water and preventing soil wash. The optimum size and intensity of contour trenching under conditions of slope and aridity, has yet to be determined. Interrupted trenches 6′ x 1½′ x 1½′ dug in parallel rows 8′ x 12′ apart centre to centre in lines 12′—15′ apart have given satisfactory results in the plantations. Alignment of the trenches is done with an ordinary mason's level mounted on a stand. The trenches are dug in winter and the dug earth is thrown on the down hill side and allowed to weather upto May. Slash if any available is stacked on the trenches and burnt in April before the trenches are refilled. Ash is thoroughly mixed with earth. On the break of the monsoon by the end of June, sowing is carried out in lines on the ridge, on the berm 4 to 6 inches away from the edge of the trench and in the bottom of the trench. In the years of heavy rainfall, seedlings will thrive on the ridge while those in the trench will suffer from excess of water. In the years of low rainfall, seedling will thrive in the bottom of the trench while those in the ridge will suffer from drought. In cases were transplants or stumps are used they are put in circular holes in the trenches. These are made before hand. At the time of planting, the earth is filled back in the holes, lightly rammed and well compacted round the stems.

Soil being a very important factor careful examination of the soils by excavating pits with clean vertical sides with a view to ascertain the physical and chemical properties of the soil is desirable

Choice of species : Due to arid conditions only xerophytic and drought resistant species are worth trying. Other essential qualities required are rapid growth, ability to stand strong winds, availability of seed, its collection and viability. Preference is given to such species as would supply fuel, fodder and if possible be useful in setting up new industries. Suitable exotics have also therefore to be tried. The following species are being tried in the experimental plantations :

Acacia arabica (*Babul*). *Acacia catechu* (*Khair*). *Acacia senegal* (*Kumath*). *Prosopis spicgera* (*Khejri*). *Tecoma undulata* (*Roira*). *Albizzia lebbek* (*Siris*). *Azadirachta indica* (*Nim*). *Ailanthus excelsa* (*Aroo*) *Prosopisjuliflora* (*Vilayati khejri*). *Phoenix dactylifera* (*Date palm*).

Prosopis juliflora mesquite (Australian form) was introduced in the old princely state of Jodhpur in the year 1915 and is spreading naturally at Jodhpur, Pali, Jalore, Nagore, Balotra and other places. The success of this species in this area has been phenomenal and it is being used on a large scale in our experimental afforestation. It is a fast growing evergreen tree, indigenous in West Indies, Mexico and Central America and has done well in Anglo-Egyptian Sudan where the rainfall is only 4″ to 8″. It was introduced in Sind in 1878 and has now been tried successfully in other parts of India. The leaves are usually not eaten by cattle but the pod provides good fodder, rich in proteins.

Presowing treatment of seed :— Soaking of seed in cold water for 24 hours before sowing generally hastens germination. The pods of *Prosopis juliflora* are broken into one or two seeded segments and soaked in water for 24 to 48 hours and *Prosopis* and babul (*Acacia-arabica*) seed which has passed through goats gives a higher percentage of germination.

Time for sowing and planting : (a) Direct sowing : If good seed is available and adequate irrigation is possible, seed is sown in March, otherwise at the break of rains. If there is a long break in the monsoon resowing may be necessary.

(b) Planting : As the number of rainy days is small and rainfall uncertain, planting is carried out as soon as the rains set in and completed as quickly as possible while the ground is wet. Early planting favours development of a strong root system which is required to withstand drought conditions during the post-monsoon period. In case of long breaks in the monsoon, watering may have to be done. Casualties are usually replaced in August.

Spacing : The usual practice of close planting is not suitable for poor soils with difficult climatic conditions. In the arid zone which lies beyond the natural forest belt, wider spacing is necessary so that the trees may develope a large crown and an extensive root system. Espacement recommended is 8 feet to 12 feet. When close spacing is adopted, early and frequent thinnings should be carried out and low density should be maintained.

Weeding and hoeing: The most critical time for the young seedlings is the first rainless period after planting. The plants survive if the roots have penetrated a depth of 10″ to 12″ provided all the available moisture has been conserved.

The following operations are necessary during the first two or three years after planting :—

(a) **Weeding**: Eradication of the annual and perennial weeds at the proper time is essential otherwise the weeds will not only suppress the seedlings but are likely to exhaust the water reserves in the soil. Two or three weedings may be carried out during the first year and atleast one weeding during the second year. Where necessary, the first weeding should start soon after the germination starts. At the time of the second weeding, during the first year where sowings have been done in lines, seedlings may be thinned so as to leave them not less than 6 inches apart.

(b) **Hoeing**: The soil round the seedlings should also be worked at the time of first weeding. Afterwards the soil surface should not be allowed to cake. If soil working is not properly attended to, there will be heavy casualties due to drought and white ants.

9. **Technique of Fixation of Shifting Sands.** There are large areas of mobile sand dunes in this desert which must be stabilised as they are a source of danger to the adjoining fertile lands, buildings, roads railway, wells etc. Most of the dunes were stable, having been fixed with natural vegetation. But excessive and uncontrolled grazing by cattle, sheep, goats and camels and lopping for generations and cultivation of marginal and submarginal lands has resulted in the removal of the protective cover of vegetation. As a consequence wind erosion has started and stable sand dunes are being transformed into mobile shifting sand. With a view to develop a technique for the fixation of shifting sands by vegetation in this desert, this research station has taken up two areas of 80 acres each this year. The following notes are based on the experience gained so far.

Firstly protection against trespass by men and animals is absolutely necessary. All existing vegetation must be conserved and soil kept intact. Where mobile sands are in an incipient stage this protection itself may be sufficient to establish a cover of vegetation with-

out much expense. In most cases, however, it has to be supplemented by artificial work.

A fence of thorns of *Zizyphus rotundifolia* which is common in this desert, about 5 feet in height and at right angles to the direction of prevailing winds has proved very efficacious in breaking the force of wind and catching the sand in addition to keeping off cattle and goats. This however, serves to hold the sand only temporarily and is not a permanent cure. To prevent movement of sand vegetation is essential. To bring this about first brush-wood is strewn or placed over the ground in density varying according to wind and drift. Then sowing or planting of indigenous xerophytic trees, shrubs, creepers and grasses is done. For brushwood, branches of trees, 8′ to 10′ long and 1″ to 3″ in diameter at butt end have proved statisfactory. The branches are so placed that the free end overlaps the butt end of the next one. To prevent rolling, they are placed lengthwise and secured by pegs, if necessary. The butt ends of the branches face the direction of the prevailing wind. When planting, it is more convenient to spread the brushwood after planting the area.

This method involving use of brushwood is expensive and should be adopted only where immediate reclamation is desired otherwise sowing or planting fast growing species in belts consisting of 3 or 4 rows fairly closely spaced at right angles to the prevailing winds is done. These wind belts are at intervals of about 200 feet. In a few years the plants in the belts are expected to afford adequate protection to anything planted in between.

Planting or sowing is commenced from the windward side.

As regards species, shrubs and grasses found growing naturally on the sand dunes are being used. *Calotropis procera* (ak) *Calligonum polygonoides* (phog), *Leptadenia spartium* (khip) *Aerua tomentosa* (bui), *Citrullus colocynthus* (tumba), *Panicum turgidum* (munt), *Elionurus hirsutus* (shewan), *Eleusine flagellifera* (tantia), *Eleusine aristata* (ganthil) and *Eleusine aegyptiaica* (makra) are being sown or planted first. After the sites have become stable, local tree species such as *Prosopis spicigera*, *Acacia senegal*, *Tecoma undulata* and *Commiphora mukul* are being used but they are slow growing. Several exotics are also being tried. *Prosopis juliflora*, an exotic, is proving quite suitable.

Soil Conservation, Anti-Erosion and Afforestation Works in Hyderabad State.

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Introduction: Hyderabad like most of the Indian States, is an agricultural country with a land area of 82,168·3 sq. miles out of which 40,474·3 sq. miles or 49·1% is under cultivation, and 12,821·99 sq. miles or 15·60% is classed as forests. These forests are not evenly distributed throughout the State. The Eastern half, comprising Telangana Districts, has abundant forests, whereas the Western half, comprising the Marathwada and the Karnatic tracts, is devoid of them, so much so, that there is an acute shortage of both fuel and fodder in the latter half. These Districts constitute the famine zones, with disturbing water-shortage conditions in summer seasons. The problem confronting the Forest Department of the State is to improve the existing forests of the Telangana zone and to reclaim the eroded lands of the treeless tracts of Marathwada and Karnatic by large scale Anti-erosion and Afforestation Works in order to improve the climatic conditions of this tract on the one hand, and on the other to provide fuel, small timber and fodder for the local consumption. The Districts, given priority for starting these operations, are Bidar and Osmanabad, both having vast stretches of badly eroded lands which have been lying fallow for many years past, affecting the productivity of neighbouring fertile lands by spreading boulders, gravel and sand thereon, specially at the foot of the hills.

2. General description of the Marathwada and Karnatic Treeless Tracts of the State: The rich black-cotton-soil lands of these tracts tempted the inhabitants to extend their cultivation at the expense of forests, so much so, that even low slopes of the steep hills were not left alone. The bumper crops they obtained from the virgin forest soil in the first few years turned them, virtually, into enemies of forests. These lands, which were once famous for the richness of their productivity and consequently, the tillers prosperity, have now become almost barren (if not desert) and all due to sheer lust of man for bringing more lands under cultivation. Progressive yearly increase

in the area of fallow lands, severe water-scarcity conditions specially in summer, constant famine or near-famine conditions are all the havocs of erosion which, although imperceptible in the initial stages has taken such a heavy toll that unless drastic remedial measures are taken to fight out the scourge, by adopting a long term programme, a very dark future is in store for these tracts. What can be a better example to throw light on the present conditions, statistically, than Bidar District where these rectifying measures have been recently started.

Photo No: 1. Overgrazed eroded area being spread with boulders of varying sizes.

Bidar District. 3 Situation: Bidar is a historical town situated at an altitude of 2,243 feet. Its latitude is 17°—55′. Average rainfall for the last 5 years was 33·3 inches. It is on the North Western side of Hyderabad city, at a distance of 84 miles, connected with it by a well maintained metalled road. The maximum temperature in summer is 105°F. and the minimum temperature in winter is 56° F.

4. Soil Condition: Due to entire removal of tree growth, the rich ferrugenous soils have lost their original fertility. The rains falling on these bare grounds have unrestrictedly performed their diabolical task of erosion and converted these regions into veritable geological shambles. Both "*Sheet-erosion*" and "*rill-erosion*" have set in, resulting in (i) washing away of top soil and (ii) formation of

gullies and ravines on the slopes. Due to the washing away and leaching of the mineral salts, the exposed ferrous compounds in the sub-soil have been oxidised into ferric ones, giving them a very hard, solid and impenetrable consistency (laterization) converting once fertile lands into extensive barren tracts, devoid even of inferior hardy grasses.

5. **Description of the area:** According to the statistics of 1951, the total area of Bidar District is 29,31, 321 acres, out of which 26,883 acres or 0·9% is covered with scrub jungle of a very open nature. Area under pasture and grazing grounds is 1,31,755 acres or 4·5%. Fallow lands (due to advanced erosion) are 7,64,253 acres or 26·0%, while the area under cultivation is 17,43,651 acres or 59·4%. Thus out of the total area of 29,31,321 acres;

1.	Scrub jungle is	0·9%
2.	Pasture & grazing ground is	4·5%
3.	Fallow land, due to advanced erosion is	26·0%
4.	Area under cultivation is	59·4%
5.	Area under rivers, roads, railways, towns and villages etc.,	9·2%

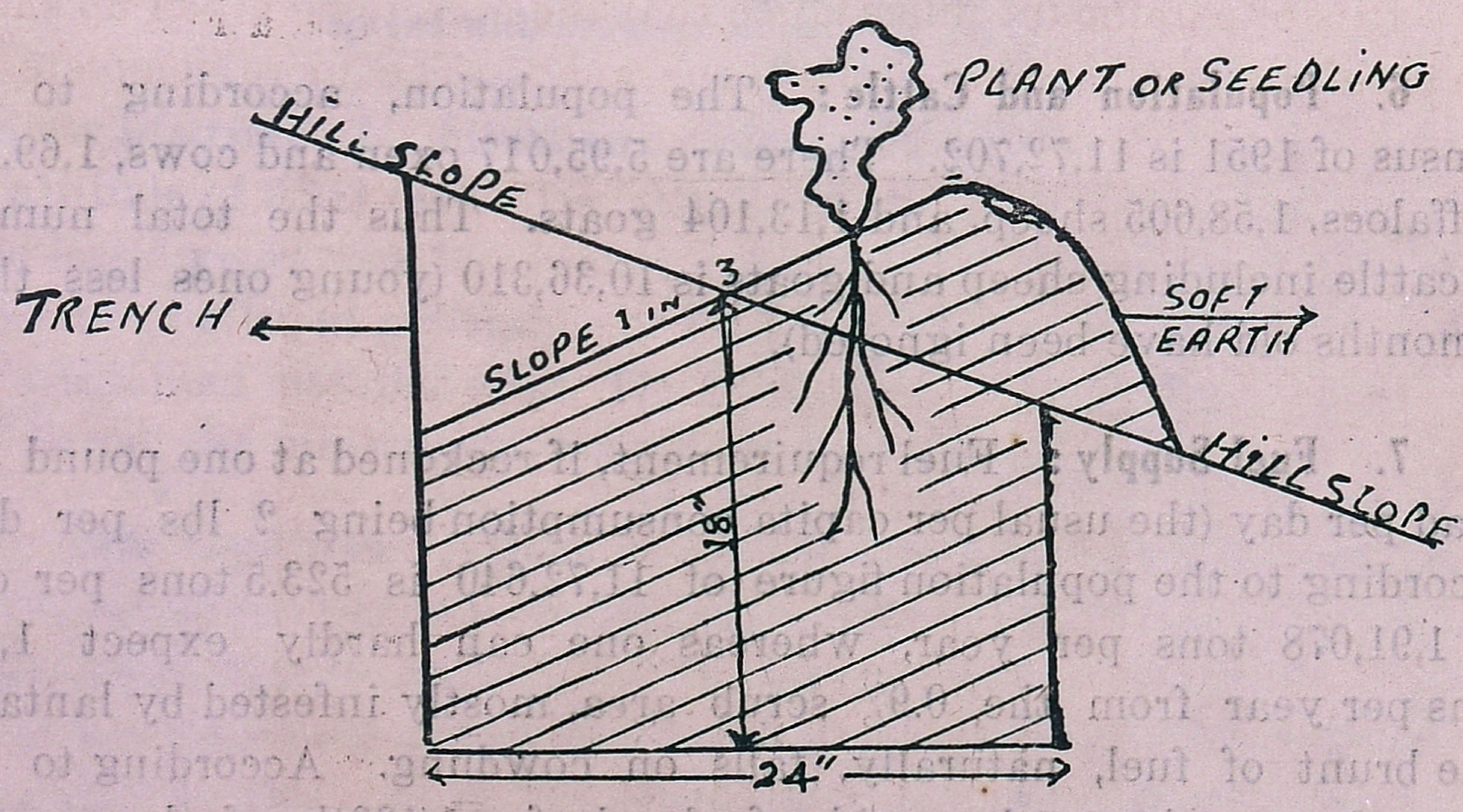
6. **Population and Cattle:** The population, according to the census of 1951 is 11,72,702. There are 5,95,017 oxen and cows, 1,69,584 buffaloes, 1,58,605 sheep, and 1,13,104 goats. Thus the total number of cattle including sheep and goats is 10,36,310 (young ones less than 6 months old have been ignored).

7. **Fuel Supply:** Fuel requirement, if reckoned at one pound per head per day (the usual per capita consumption being 2 lbs per day) according to the population figure of 11,72,640 is 523.5 tons per day or 1,91,078 tons per year, whereas one can hardly expect 1,000 tons per year from the 0.9% scrub area, mostly infested by lantana. The brunt of fuel, naturally, falls on cowdung. According to the above figures, the scrub provides fuel only for 1/190th of the population; the rest has to resort to dung cakes and if these are reckoned at

1/10 lb. per head per day, the total quantity consumed in a year would be 18,608 tons of valuable manure, which could be diverted to produce more food by manuring the agricultural fields.

(8) **Grazing conditions:** The area of the scrub jungle is 26,883 acres and that of the pasture is 1,31,755 acres, the total being 1,58,638 acres. Fallow lands are in an advanced stage of erosion. In fact sheet rock has appeared and hence they produce nothing except stray blades of tussocky grass in the crevices. Therefore, these fallow lands, as far as grazing is concerned, are next to negligible. If the cattle is converted into units of cows, the total would be equivalent to 10,03,836 cows. According to these figures the unit of grazing works out to 0·15 acres per cow. This is far below the subsistence level.

(9) **Rectificatory measures adopted:** The conversion of these large barren tracts into some sort of productive land is no easy task. The first step in this direction is to eradicate the evil of erosion and prevent rain water rushing off into ravines by arresting the velocity of run-off by means of contour trenches and gully plugging. The next step is to establish some sort of vegetation and afforest the area with hardy species. The methods adopted here aims at conserving the soil and moisture through trenching and gully plugging and then establishing vegetative cover which comes up naturally in the form of



grasses as the result of increased moisture content in the trenched area. Continuous contour trenches of Gradoni type - (2′ X 1½′ in cross-

section) are adopted and partially filled back with the dug out earth - the filling forming a slope of 1 in 3 with a ridge on the sloping side. Hardy fuel species are then introduced on the slope fillings by direct sowings or by transplants and cuttings.

It is a mistaken notion that one can establish forests in such areas with a single attempt which would yield cash returns in the immediate future and that any amount spent on the reclamation of such lands should be judged in terms of the establishment of a dense jungle which will catch the common eye. If these barren lands are made to produce only grasses, the very first step of reclamation would have been achieved. What is actually needed is the right type of operation, patience and perseverent working and observation. It requires the combined resources of an Engineer, a Forest Officer and an Agriculturist to fight against the ravages of erosion.

For the typical conditions prevailing in this district the technique developed is strictly based on contour trenching the area by dividing the extensive slope into compartments; this prevents excess water from the compartment above, entering the compartment below, so that each compartment in the trenched area carries only that amount of water which directly falls upon it in the shape of rains. Since the water supply is thus restricted, subsequent control over any surplus water on a particular unit is greatly simplified.

It is of paramount importance that the area to be taken up should be carefully studied *vis-a-vis* its topography. The more complete the

Photo No: 2. Contour trenching work in progress.

reconnaissance the easier would it be to plan the lay out and subsequent supervision of the operations. It is also important to know the slope of the country in order to determine the vertical fall between the trenches. Fixation of distance between the trenches is of vital importance, for on it depends the area of land that will drain into the trench.

10. Slope Percent Formulæ : The formulæ and the tabular statement computed from it given below will serve as a guide for determining :

(i) Vertical fall between two adjacent trenches and

(ii) Horizontal distance between them for a particular slope percent.

FORMULÆ.

(i) For determining the vertical fall V for a given slope (n)% is V = [5/2 + (n—1)¼] feet

and

(ii) For finding out the horizontal distance H for a given slope (n)% is H = V/n X 100 feet.

Example :— The vertical fall and the horizontal distance between two trenches in an area of 2% general slope, according to the formulæ will be as follows :—

(i) V = 5/2 + (n—1)¼ feet
V = 5/2 + (2—1)¼ „
V = 11/4 = 2¾ „
V = 2 ft. 9 inches

(ii) H = V/n × 100 „
= 11/4 × ½ × 100 feet
= 11/8 × 100 feet
= 137·5 feet

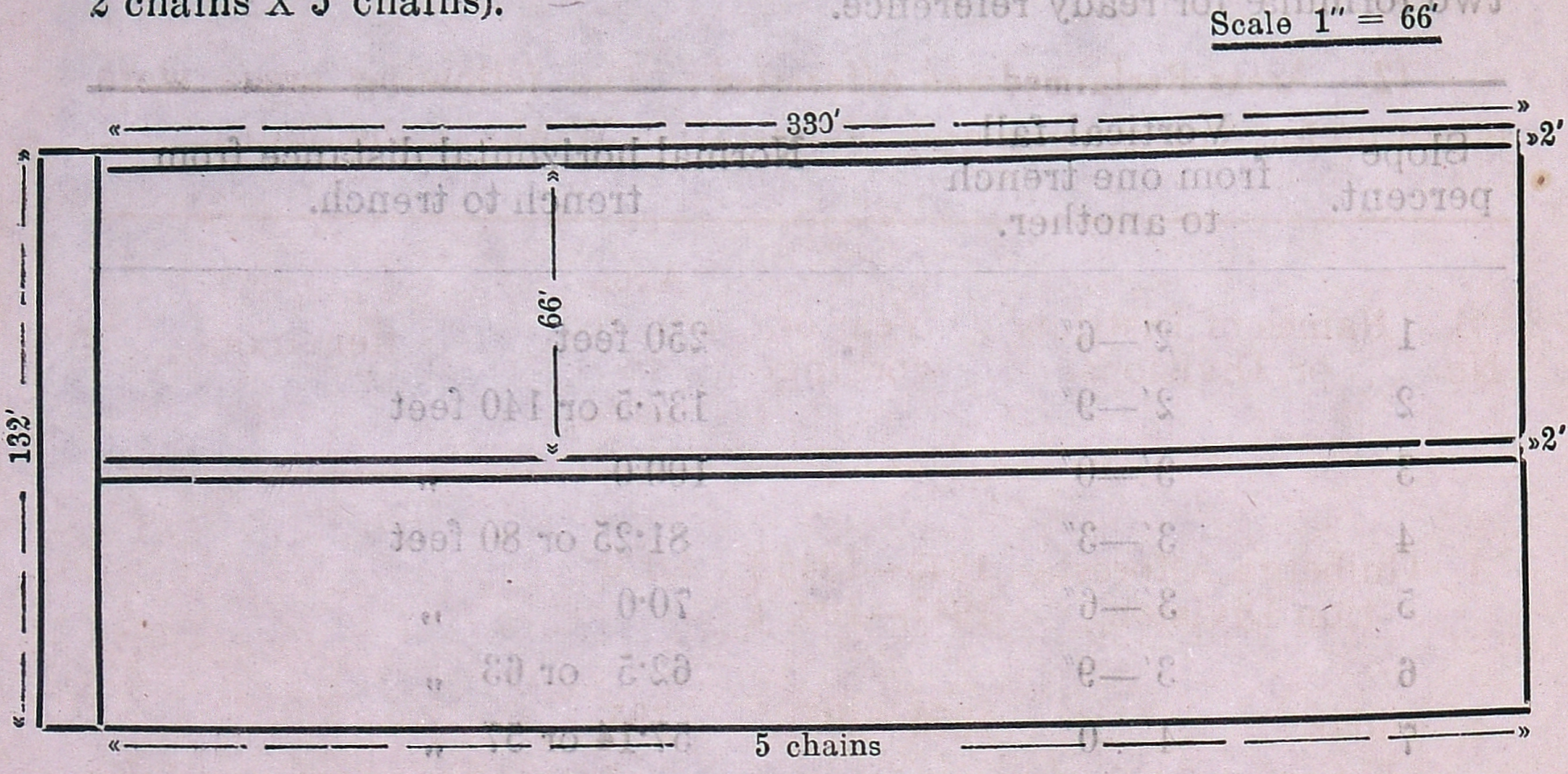
The following tabular statement has been derived from the above two formulæ for ready reference.

Slope percent.	Vertical fall from one trench to another.	Normal horizontal distance from trench to trench.
1	2′—6″	250 feet
2	2′—9″	137·5 or 140 feet
3	3′—0″	100·0 ,,
4	3′—3″	81·25 or 80 feet
5	3′—6″	70·0 ,,
6	3′—9″	62·5 or 63 ,,
7	4′—0″	57·14 or 57 ,,
8	4′—3″	53·12 or 53 ,,
9	4′—6″	50·0 ,,
10	4′—9″	47·5 or 48 ,,

11. Dimensions of trenches: In order to fix the dimensions of trenches, daily rainfall figures of at least for the past five years should be scrutinized and the average rainfall and deviation from it carefully studied. As far as such districts are concerned, for all practical purposes, 0·5″ rainfall can be taken as maximum for which provision has to be made (actually 0·1″ is the rainfall for maximum number of days in the rainy season in Bidar District). The excess over 0·5″ will be the drain off. Economical considerations *i. e.* the funds available also reflect on the dimensions of the trenches to be fixed. *Thus the average slope of the land fixes the trench distances and the daily rainfall the dimensions.*

At the time of starting these pioneer works in Bidar District in 1945, little attention was paid to these basic facts and the distance between two adjacent trenches was fixed arbitrarily at 150 feet. Later on this distance was given up and in the First Five Year Development Scheme it was reduced to 66 feet as an experiment. An acre will

thus coutain two trenches 66 feet apart (assuming this acre to measure 2 chains X 5 chains).



The cubical contents of these trenches of 2 feet X $1\frac{1}{2}$ feet cross section is 2 X 3/2 X 330 = 990 c. ft; these trenches in a plot of ½ acre are capable of holding 990 X 6·2 = 6,138 gallons, whereas 0·5" rainfall in one day on half-acre plot would precipitate $\frac{4840x9x0{\cdot}5x6{\cdot}2}{2x12} = 5{,}626{\cdot}5$ gallons of water. The proportion of water capable of being conserved to that of the rainfall is 6138 : 5626 :: 1 : 0·9. Thus provision is made for higher capacity trenches than would actually be needed. In other words these trenches are capable of holding daily rainfall of slightly more than 0·5". Experience has shown that the general trend of the slope is not so steep as to justify 66 feet horizontal distance between the trenches, hence, necessitating revision.

Under the Five Year Development Plan operations for 1953-54, after taking into consideration average general slope of the land the trench distance has been fixed at 132ft. Thus there will be only one trench of 2 ft. X 1½ ft. per acre, with a water holding capacity of 6,138 gallons. 0·5" rainfall a day works out to a precipitation of 11,253 gallons per acre. In other words, by adopting this espacement, the proportion of water conserved to that which would be lost in run-off would be 1 : 0·8. Grass is coming up profusely in the intervening trench spaces, which would no doubt arrest this run-off, hence the

revised espacement would serve all practical purpose as also be comparatively more economical.

12. **Areas Reclaimed and Afforested :** The following areas were taken up for Anti-erosion and Afforestation Works in the State:

S. No.	Names of Districts or Divisions.	Year of working.	Area covered in acres.	Remarks.
1	Gulberga Afforestation Division.	1945—1946 1947—198 }	4,020	
2	Bidar.	1950—1951	195	
3	Bidar & Osmanabad.	1951—1952	2,150	The work was hapazard prior to 1951—52 but since then it has been systematically executed under the First Five Year Development Plan of the Forest Department.
4	,, ,,	1952—1953	760	
5	,, ,,	1953—1954	5,259	,, ,,
6	Advance trenching work in Bidar, Osmanabad, Hyderabad and Aurangabad.	1953—1954	5,802	,, ,,
	Total		18,186	

13. Species tried and Growth Data: The following species were tried initially by direct sowing and planting of seedlings and stumps on the slope fillings of trenches, in Bidar District.

S. No.	Species.	Best method of introduction	Average height & girth of Afforestation areas established in the following years as recorded in January, 1954. 1945 Avg. ht. ft.	1945 Avg. gir. inches	'51-'52 Avg. ht. ft.	'52-'53 Avg. ht. ft.	'53-'54 Avg. ht. ft.
1	2	3	4	5	6	7	8
1	Acacia arabica	Sowings	12	14	4	3½	1½
2	Ailanthus excelsa	Sowings	—	—	3	2½	1
3	Albizzia lebbek	Sowings	12½	13	5	3½	1½
4	Anacardium occidentale	Sowings	—	—	—	3½	1½
5	Anona squamosa	Sowings	—	—	3	2	1
6	Azadirachta indica	Sowings	12	8	3	2	1
7	Bauhinia variegata	Sowings	—	—	—	3½	2
8	Bombax malabaricum	Transplanting	10	9	—	1½	1
9	Butea frondosa	Sowings	8	8	2	1½	9″
10	Cassia fistula	Sowings	8	6	2½	1½	6″
11	Cassia siamea	Sowings	22	18	8	4	2
12	Dalbergia sissoo	Stumps	10	9	5	3½	2
13	Dendrocalamus strictus	Rhizome	20	—	2	9″	2″
14	Glyricidia maculata	Sowings & stumps	—	—	6	3	1½
15	Hardwickia binata	Sowings	—	—	2	1	6″
16	Inga dulcis	Sowings	—	—	—	—	1
17	Pongamia glabra	Sowings	—	—	4	3	1½
18	Melia azedarach	Sowings	12	7	5	3	1½
19	Prosopis juliflora	Sowings	10	9	—	4	2
20	Tamarindus indica	Sowings	8	6	2	1½	9″
21	Sapindus emarginatus	Sowings	7	4	2	1	9″
22	Semecarpus anacardium	Sowings	8	6	3	2	1
23	Terminalia belerica	Sowings	12	8	3½	2½	1½
24	Zizyphus jujuba	Sowings	5	4	3	2½	1

14. Moisture contents of the Soil in the Trenched and Untrenched Area: The Experiments were carried out to determine the moisture content of the trenched and the untrenched area and the results obtained are interesting. Soil samples (fixed column measure to a depth of 21″) were taken from randomised spots fixed in the trenched and the untrenched areas and their moisture free weights were determined. The results of the experiments carried out in the month of February, 1953 are as follows :—

Graphic representation of Moisture contents of Trenched and Untrenched areas of Bidar district at different depths.

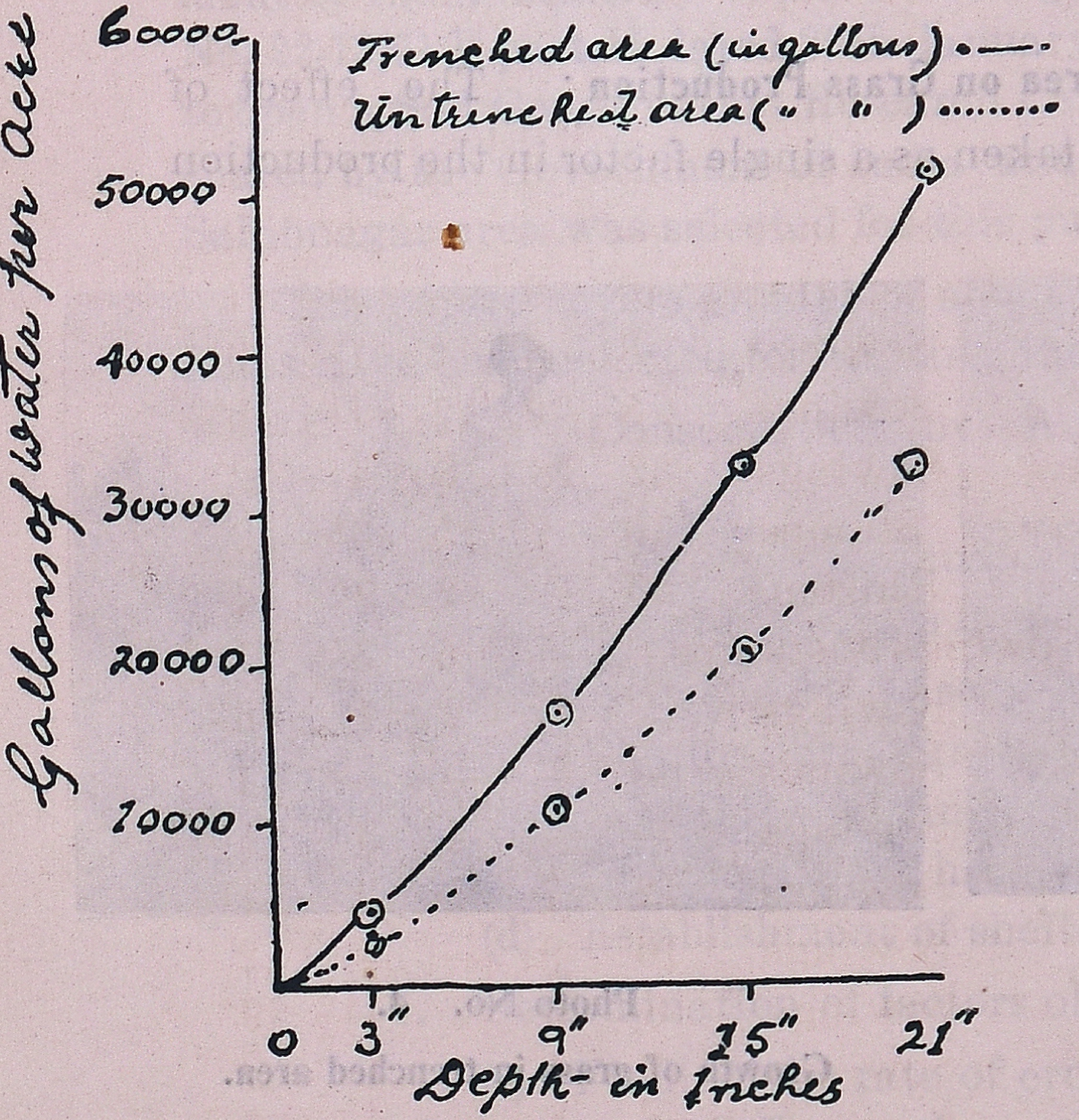
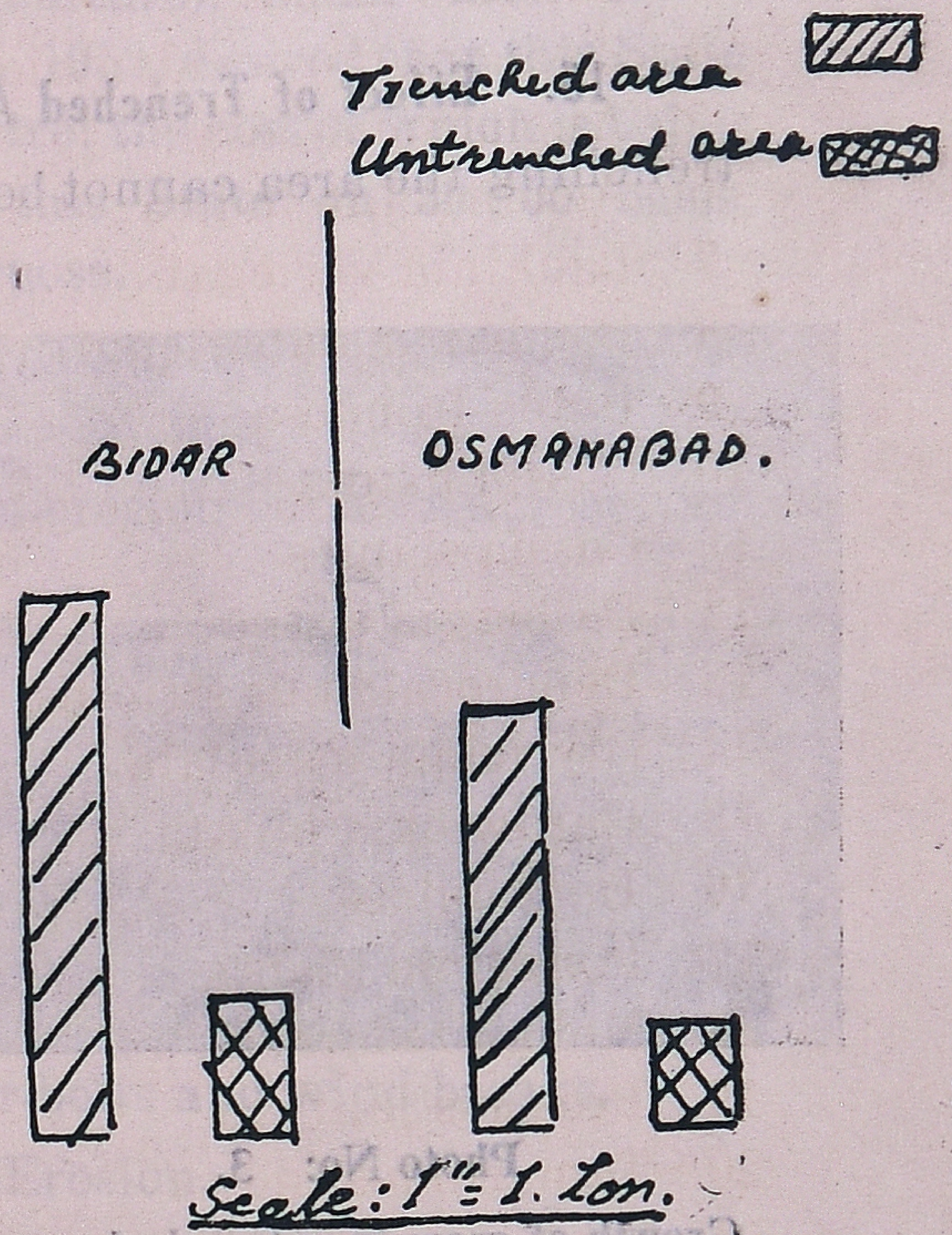


Chart showing the production of grass in the Trenched and Untrenched areas of Bidar and Osmanabad District



S. No.	Soil depths	Moisture contents in Gallons of Water per Acre. Trenched area	Untrenched area	Difference.
1	(0—3)″	4,719	2,907	1,812
2	(0—9)″	17,031	10,567	6,464
3	(0-15)″	32,626	20,588	12,038
4	(0-21)″	50,581	32,216	18,365

The ratio of moisture conserved in the trenched area as compared with the untrenched determined to a depth of 21″ (from the surface) is 1·6 : 1.

15. Effect of Trenched Area on Grass Production: The effect of trenching the area cannot be taken as a single factor in the production

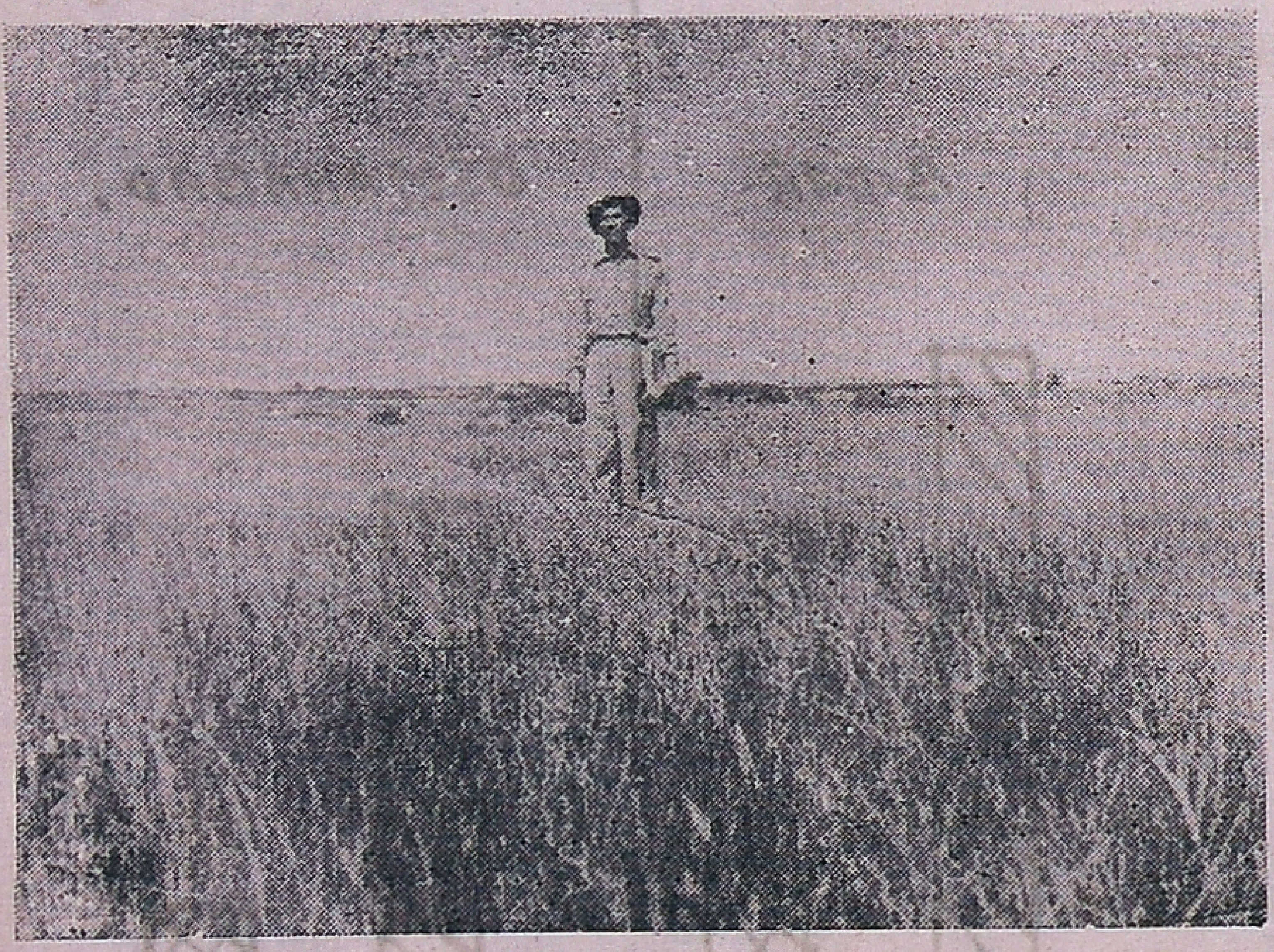


Photo No: 3.
Growth of grass in untrenched area.

Photo No. 4.
Growth of grass in trenched area.

of grass. Here, along with the trenching the area, complete protection from fire and grazing also come into play. Due to the increased moisture content of the trenched area, a decidedly beneficial effect is

produced on grasses and their growth is accelerated. The following table compares the productivity of grasses in the trenched and untrenched areas, protected against grazing and fire.

Districts.	Yield per Acre		Difference + or —
	Trenched area.	Untrenched area	
Bidar	1·5 tons	0·4 tons	+1·1 tons
Osmanabad	1·15 ,,	0·3 ,,	+0·85 ,,

The above data is a proof positive of an increase of 275% yield of grass in Bidar and 283% in Osmanabad.

16. Sahibnagar Soil Conservation Research Centre: The Government of India (Ministry of Food and Agriculture), under their letter No. 22-13/61 F part II dated 29th January, 1953, desired that this State to open a Soil Conservation Research Centre; the cost of which is being shared by the Government of India and this State on 50 : 50 basis. Sahibnagar area was selected for this purpose.

This centre covers an area of about 1,100 acres, out of which 50 acres have been selected for starting the following experiments.

1. Soil Conservation by Anti-erosion and Afforestation devices.
2. Detailed ecological studies of the succession of vegetation in these eroded areas under rigid fire and grazing control.
3. Studies in the response of badly eroded lands to
   (a) Elimination of grazing and fire.
   (b) Trenching, pitting, gully plugging
   (c) Introduction of hardy fuel species
   (d) Establishment of shelter-belts and wind breaks.
4. Determination of factors of Erosion.
   (i) Finding the rate of erosion.
      (a) On different slopes
      (b) Under different rain velocities
   (ii) Rate of run-off under different rain velocities and intensities.

17. Experiments carried out in 1953—'54: No. 1 Determination of suitable species: In order to determine the species that are likely to do well in eroded sandy loams derived from granitic gneiss formations, under an average annual rainfall of 30 inches, an area of 25 acres representing the average conditions of these tracts was selected. Continuous contour trenches with a cross-section of 2′ X 1½′ and 132′ apart (according to the slope percent of the area) were dug, the dug out earth was re-filled so as to form a slope of 1 in 3 and ridge was formed on the lower side with the remaining earth. Each trench was serially numbered and divided into equal sections according to the number of species (30) to be tried. The sowing was done with known quantity of seeds in three rows 2½″ apart and the seeds themselves dibbled 2 inches apart on the slope filling of the trench. Species were sown in randomising fashion (picking species chits from a box). The following statement gives the germination percent, the minimum, maximum and average heights as recorded on 31st March, 1954.

S. No.	Species No.	Name of the species.	Germination %	Date of observation 31—3—1954. Min. ht. in inches	Max. ht. in inches	Avg. ht. in inches
1	2	3	4	5	6	7
1	22	Melia azedarach.	70	10	36	24
2	25	Albizzia lebbeck.	63	10	20	15
3	27	Glyricidia maculata	48	12	28	20
4	23	Anona squamosa	47	1	6	3½
5	26	Bauhinia variegata	43	2	41	22
6	16	Leucaena glauca	40	3	33	18
7	6	Zizyphus jujuba	17	2	27	14
8	17	Acacia arabica	16	2	25	15
9	3	Cassia siamea	15	1	20	12
10	29	Prosopis juliflora	14	1	47	25

contd.

S. No.	Species No.	Name of the species.	Germination %	Date of observation 31—3—1954. Min. ht. in inches	Max. ht. in inches	Avg. ht. in inches
1	2	3	4	5	6	7
11	7	Anacardium occidentale	12	2	22	14
12	10	Ailanthus excelsa	12	6	19	10
13	24	Parkinsonia aculeata	11	2	56	32
14	9	Dalbergia sissoo	9	2	23	14
15	20	Pithecolobium saman	7	2	17	9½
16	28	Butea frondosa	7	1	10	6
17	30	Prosopis spicigera	7	1	4½	4
18	18	Sapindus emarginatus	6	1½	15	9
19	15	Terminalia belerica	6	1	8	4
20	5	Eucalyptus (Bidar var.)	6	3	34	19
21	4	Pongamia glabra	5	2	14½	9
22	19	Hardwickia binata	4	2	11	7
23	14	Semecarpus anacardium	3	1	4	3
24	8	Azadirachta indica	3	2	18	12½
25	13	Buchanania latifolia	1	1	4½	4
26	11	Bombax malabaricum	0·4	1	11	5
27	2	Diospyros melanoxylon	0·2	—	—	—
28	12	Strychnos nux-vomica	0·1	1	11½	9
29	21	Albizzia amara	—	—	—	—
30	1	Tectona grandis	0·1	½	2	1½

The above statement shows that at this stage the following species hold out hope for the future.

1. Acacia arabica
2. Ailanthus excelsa
3. Albizzia lebbeck
4. Anacardium occidentale
5. Azadirachta indica
6. Bauhinia variegata
7. Cassia siamea
8. Dalbergia sissoo
9. Eucalyptus (Bidar var.)
10. Glyricidia maculata
11. Melia Azedarach
12. Prosopis juliflora

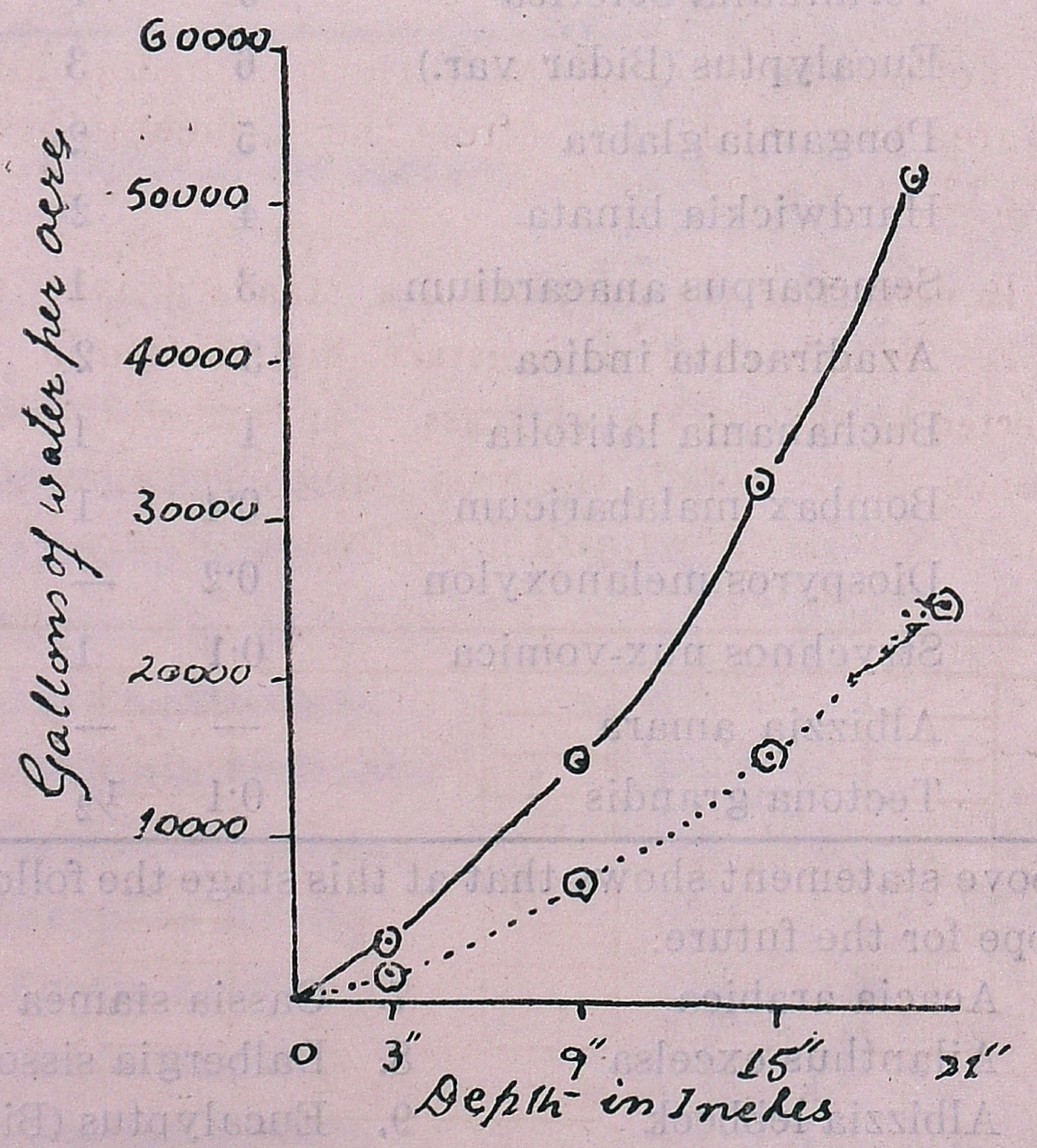
No. 2. Determination of Rate of Erosion : A one-acre plot was laid out to determine the rate of wash-off by arresting silt in the silt traps. The results so far recorded indicate that 13·7 c. ft or 1,556·8 lbs. of silt was washed off from one acre in a total rainfall of 31·13″ from the month of August 1953 to the end of October 1953.

No. 3 Effect of trenching on moisture content of soil during different periods of the year. In one-acre plots soil samples were taken from

Graphic representation of Moisture contents of Trenched and Untrenched areas of Sahibnagar Soil Conservation Research centre at different depths.

Trenchdd area (in gallons).—.

Untrenched area (in gallons).....



randomised spots in the trenched and untrenched area. The results as recorded on 15th February, 1954 are as follows :

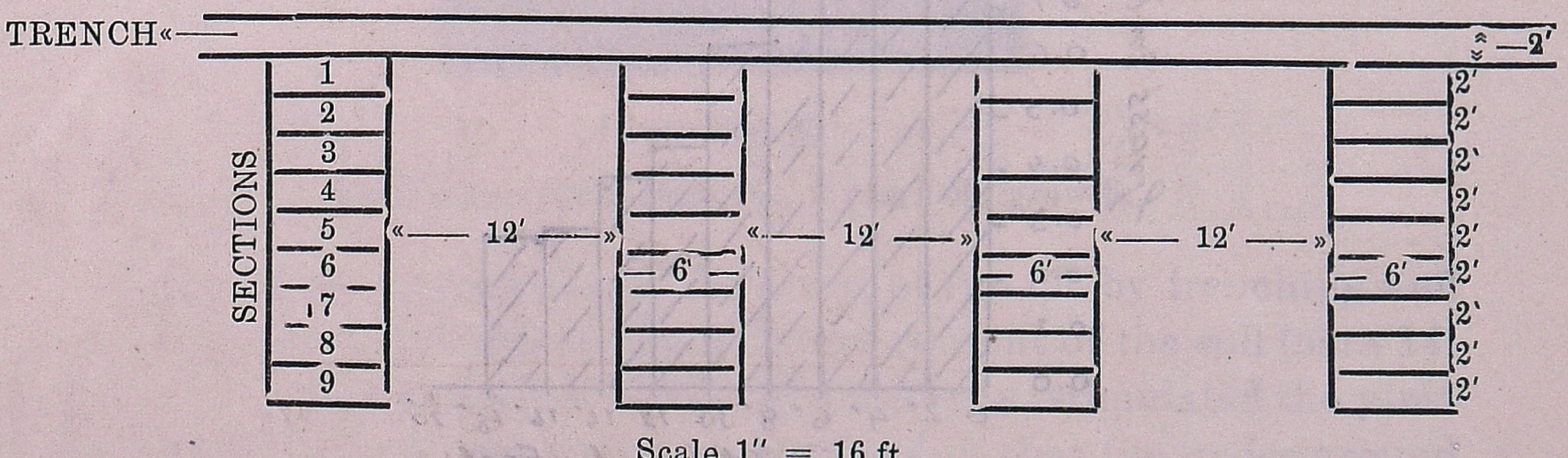
S. No.	Soil depths in inches.	Moisture content in gallons of water per acre.		
		Trenched area	Untrenched area	Difference
1	0—3	3,215	1,607	1,608
2	0—9	14,159	6,805	7,354
3	0—15	31,122	14,159	16,963
4	0—21	49,590	22,264	27,326

Graph representation of the above figures given above shows the vast differences between trenched and untrenched areas.

In the trenched area the run-off gets absorbed in the trenches and inter-spaces.

The ratio of moisture conserved in the trenched area to that in the untrenched area to a depth of 21″ (from the surface) in a total annual rainfall of 31·13 inches is: 2 . 2 : 1

No. 4. To determine the influence of a standard type of continuous trench (2′ x 1½′ cross-section) on moisture distribution in the adjoining tract as reflected by the growth of grass. In order to determine the above influence of the trench, the area lying just below it was divided into sections 6′ X 2′ as shown in the following figure.



Scale 1″ = 16 ft.

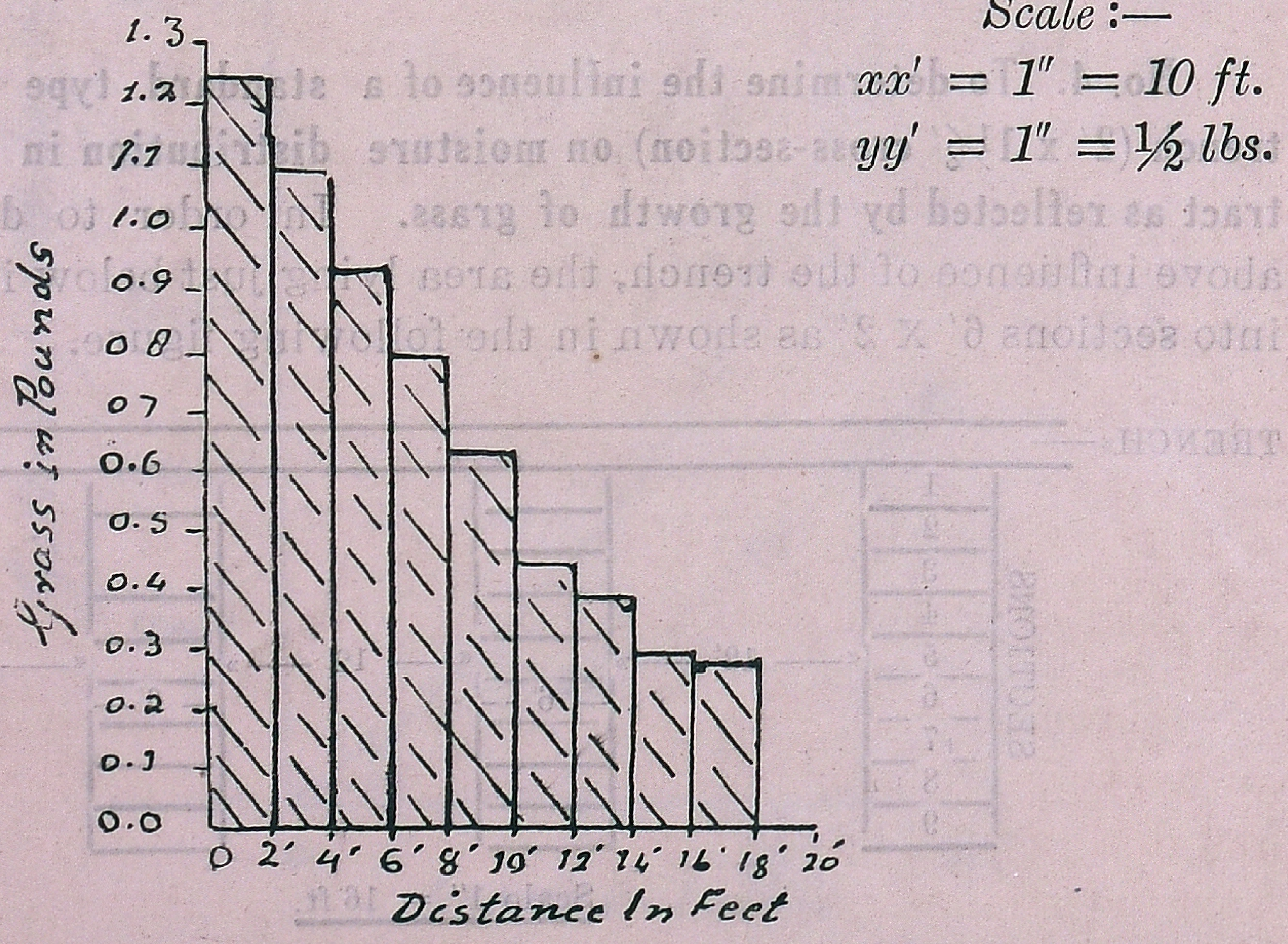
Grass from each section was cut and dried. The dry weight of grass from each section was recorded till the weight of grass in the

lowest section equalled the weight of grass from the first section of the same dimensions laid out in the control (untrenched) area.

S. No.	Distance of the section from the trench	Dry weight of grass in sections (6′ X 2′) of treated area. lbs.
1	0′—2′	1·242
2	2′—4′	1·094
3	4′—6′	0·945
4	6′—8′	0·789
5	8′—10′	0·632
6	10′—12′	0·443
7	12′—14′	0·362
8	14′—16′	0·297
9	16′—18′	0·269

Dry weight of grass in the first section (6′ X 2′) of the control (untrenched) area........................... = 0·273 lbs.

Chart showing the production of grass in (6′ × 2′) sections to show the effect of the distribution of moisture of a trench (2′ × 1½′) cross-section.



The above figures and graph show that the effect of moisture spread of the trench equalises itself with that of the untrenched area at a distance of 17⅘ feet.

No. 5 To study the ecological sequences of herbs, shrubs and trees under rigid protected conditions. Recording of the succession of species responding to strict fire and grazing control was done in 1 sq. yard quadrats in 3 transects. The existing natural growth was classified into 2 categories viz:—

i. Grasses ii. Weeds

So far i. 13 Grasses and ii. 38 weeds (mostly annuals) have been recorded and pressed specimens preserved.

18. Conclusions: Reclaiming such vast areas in a limited period is not an easy task. The State Forest Department has, however, tried its level best in completing the task. The results achieved are not only encouraging but have been appreciated outside the State as well

Photo No: 5.
Final stage of reclamation. 8 years old growth.

As already discussed above, the arrest of run-off by trenching and gully-plugging has increased the moisture content of the soil (para 14) and this, in turn, has both directly and indirectly, stimulated the yield from the adjoining Agricultural lands. The fact that the under-ground water table has risen is borne out by the depth of water in the wells adjoining the trenched area whereas formally these wells used to go dry during the hot season, they are now having sufficient water for

village use in that season also. Grasses are coming up luxuriantly after contour trenching in tracts where nothing could grow previously (para 15) and they are yielding an average revenue of Rs. 5,679/- per annum from an area of nearly 7,000 acres. Systematic research started in the Soil Conservation Research Station Sahibnagar (para 16) is throwing light on different aspects of Soil Conservation and will serve as future guide for similar operations in the Deccan and the surrounding States having analogous conditions.

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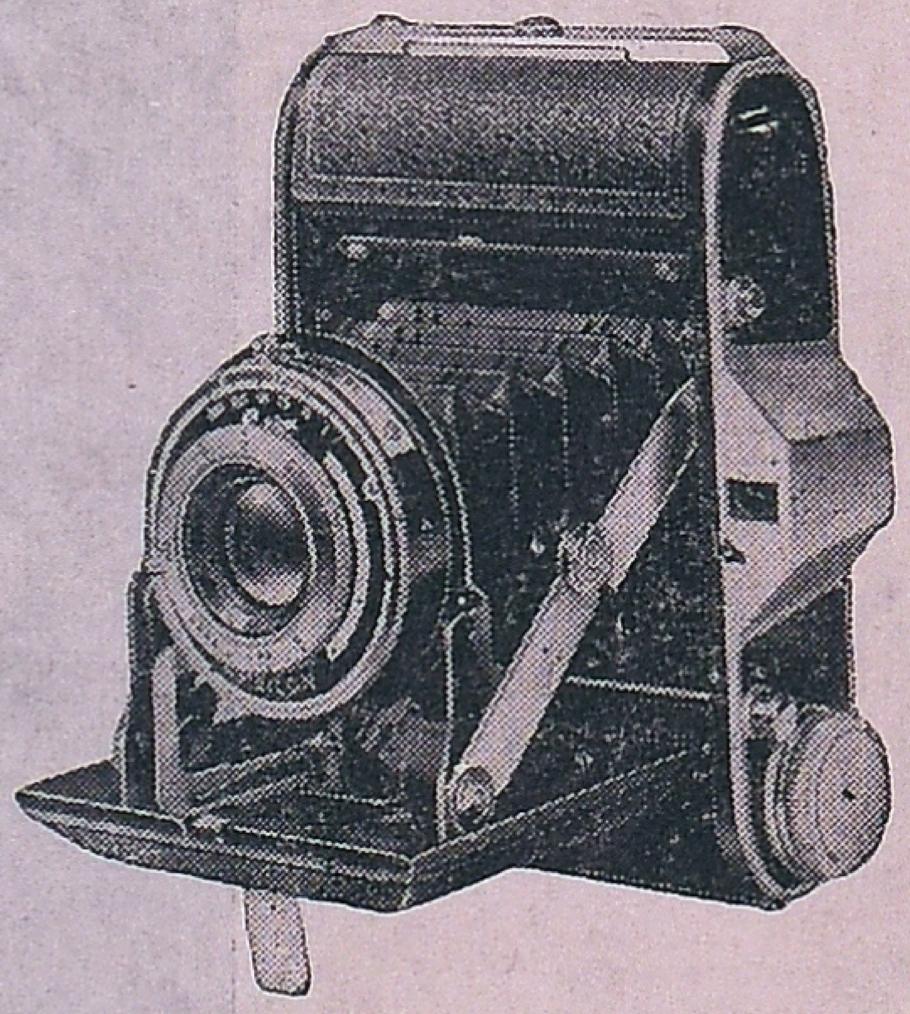

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Engineering in Soil Conservation.

By Sri S. Narayanaswamy

Assistant Agricultural Engineer, Soil Conservation Scheme, Ootacamund.

Introduction : It is the intention of the author of this article to bring out some of the Engineering aspects that have a definite bearing on soil erosion and its control. It is not in any way exhaustive and does not cover the minutest details of the designs of structural measures of soil conservation in as much as the two subjects ENGINEERING and SOIL CONSERVATION are too vast to be explained in detail in this short article. This is only to explain how Engineering can also play a part in the co-ordinated effort to prevent soil erosion. For, Soil Conservation is not a single branch of science, but a combination of various branches of science viz., geology, soil science, forestry, agriculture, ecology, engineering, etc.

Soil erosion, as is well known, is the process of displacement of the top soil from one place to another due to the action of water or wind. This takes place due to the vertical action by which the insoluble salts are leached out resulting in the reduction of crop production, as well as the lateral displacement of soil particles and their fertility by the action of run-off water or wind.

This article is intended to explain in brief the lateral action of the run off water, its deleterious effects on permanent crop production and the mechanical means that are necessary to combat the same along with other biological aspects of soil conservation.

Soil Erosion and its Causes. Of the various causes like Climate, Topography, Rainfall, Soil Type and nature of surface cover, the first three aspects of nature are beyond human wisdom to alter. Yet, it is possible to devise proper ways and means to harness these gifts of Nature in whatever form or quantity they are received and at the same time protect the lands from being eroded. By the application of suitable manures, it is possible to improve the texture and structure of the soil and to create a condition that will be advantageous to profitable agriculture and at the same time resist erosion hazards. By judicious selection of suitable crops and adoption

of Conservation Farming, it is possible to induce suitable protection to the surface of the land against the direct action of the rainstorms in eroding the valuable surface soil during the periods of heavy and ill-distributed rainfail, which are the critical periods of soil erosion.

The two most important agents that induce soil erosion and call for the knowledge or engineering principles are (1) Rainfall and (2) Topography.

Rainfall : This is the one important factor that contributes to the supply of moisture, so essential for proper plant growth - as well as erosion menaces, if not properly utilised. The rainfall is never received in the required quantities nor at the correct time and at the correct place. Either it pours in cats and dogs or it does not rain at all. In either case the normal crop yield is affected adversely as the result of severe surface soil wash; and a great portion of the rainwater is lost as surface run-off. Much therefore depends upon the collection of surface run off water after rains and regulating its flow which has a great bearing in the displacement of the productive layer of top soil. The many factors influencing the amount of run-off water and its erosive power are : (1) Precipitation, its intensity and distribution, (2) Catchment, the type and shape, (3) Topography and (4) Soil and surface vegetation.

1. Precipitation: It is well known that the greater the amount of rainfall on a particular catchment having certain particular conditions, the greater will be the depth of water accumulated for run off. The power of the water to tear off the soil increases with the depth of surface water and therefore the soil loss in this respect will increase.

The distribution of the annual rainfall among the different seasons as also the frequency and intensity have also an important bearing on the rate of run off. If a greater portion of the rainfall were received in a lesser number of days, the rainfall is said to be ill-distributed. The result will be accumulation of a greater amount and depth of surface water which means loss of tremendous quantity of silt with rain water. On the other hand, if the rain is well distributed and spread over a larger number of days, the losses will be proportionately less.

2. Catchment: "Catchment" is the area through which the rainwater sheds towards the same place or direction. As such this has also a great bearing on the rate of run off and soil erosion. If the catchment in question were located in a place experiencing more rainfall of more frequency, the run off will be proportionately high and the extent of erosion will also vary proportionately.

Since the catchment contributes to the run off draining towards the same place or direction, the quantity of run-off water and its depth will vary according to the size of the catchment. Therefore for the same amount of rainfall, the depth of surface flow will be greater in a smaller catchment, the erosion losses being proportionately greater and *vice-versa.*

The shape of the catchment in question has also a great influence on the run off and erosion menaces. If the catchment having a certain slope is narrow and long, the time taken for the surface water to reach the bottom will be longer than that taken in a narrower and shorter catchment of the same slope. Due to the length of travel in the former catchment the surface water will begin to gather increased momentum nearer to the bottom and tear the soil particles. Whereas, in the latter catchment the accumulated water will rush through to the bottom in a much shorter time than in the former one, thus allowing much less time for the soil to absorb and hold the surface run off water. And as such, the loss of run-off water will be proportionately greater than that experienced from the narrower and longer catchment.

3. Topography: The slope of the terrain is yet another important factor influencing run-off water. The steeper the slope, the shorter will be the time that will be taken by the run-off to reach the bottom. The greater will therefore be the rate of run off and its losses. According to the law of hydraulics the law of falling bodies also holds good in the case of accumulated run off rushing through from a higher level to a lower level. As such, the greater the slope, the greater will be the velocity of run off water; and this will vary according to the square-root of the vertical drop or fall in level. Therefore the velocity of the surface flow over a land

having a slope four times greater than that over the other will be twice as much as that attained by the run off on the other land. As represented by the Kinetic energy, the power obtained to tear the surface soil layer will increase four-fold in this case, if the velocity of the surface flow is doubled. The amount of a given size of silt that will be washed down will increase 32-fold ; and the size of the soil particles that can be carried through by this increased velocity will increase sixty-four fold.

4. **Soil and surface vegetation :** The erosive properties of the soil (friable nature, less in fertility, stablity and absorptive capacity, etc.) have also equal influence in increasing or decreasing the rate of run off and the erosion losses. Just as every one, man or beast, has the eagerness to protect and keep in safety the valuables, Nature also tries to protect its well earned and valuable top soil which is rich in organic content and as a result fertile, open textured, and capable of absorbing and holding more of rain water ; and will always strive to develope profuse growth of vegetational cover or increase the foliage of the cultivated crops which would not only serve as cover canopy to protect the top soil against the vagaries of the rain and climate, gain power to resist the flowing run off but also reduce the rate of run off and thereby the velocity and the loss of the valuable top soil. As such the surface vegetation growing on the fertile, stable and permeable soil, has great influence in reducing the rate of run off and soil wash to an appreciable extent. This is especially true when the rainstorms are of shorter duration and the frequency is lesser.

Control Measures : As already stated, the natural protection by the vegetative cover aids not only to enrich the soil and make it more stable and permeable but also to prevent soil erosion, and control the same to the minimum extent. But, when the natural protection is destroyed by tillage and cultivation of food and other crops, the land will be quite exposed to the dangers of soil erosion. Man cannot avoid destruction of this natural protective cover, for he has to meet the requirement of the growing population and the growing civilisation for all materials of food and clothing etc. In doing so, care should be taken that the tillage operations do not result in disaster to the

lands by way of soil and water losses. This will be possible only by careful pre-planning and determining the limiting factors that are to be considered while taking up such cultivation.

Of the various limiting factors, the slope of the land is the most important one. The maximum limit of the slope upto which Conservation Farming can be followed with advantage should be pre-determined with due regard to the type of soil and the crops to be grown, since the soil vary in erosivity and the crop growth, and in water holding power. Other conditions to facilitate tillage operations should also be considered.

As far as possible action should be taken to protect the land with the various agronomical practices of anti-erosion like Contour Cultivation, Strip Cropping, Rotational cultivation, improved agricultural practices including judicious manuring, selection of crops and strains of seeds, etc. When it is noticed that it is impossible to protect and preserve the land by adopting such biological means alone, mechanical means like Contour bunds, Contour Terraces, Contour Trenches, Gully plugging, Construction of reservoirs or ponds etc., should be adopted. In addition, other agronomical means as detailed above should always be augmented.

In fact, the general engineering principles of (1) Retarding the velocity of the surface run-off, (2) Increasing the time of concentration to make the soil absorb and hold more water and reducing the rate of surface run-off and its power to erode soil, are all implied in the biological erosion control measures also. Provision of ridges and furrows along contours, *i. e.*, across the slope as in contour cultivation, enables resistance to the surface run-off in successive stages through the ridges which act as dams to retain the run-off water in the furrows which act as reservoirs. Similarly in Strip Cropping the erosion resisting strips of crops are so provided that the velocity of the run off water emerging from the erosion permitting strip may be retarded to a point below the critical velocity beyond which the surface water cannot carry the soil particles in suspension. Soil deposition therefore will take place in every alternate strip of erosion resisting crop, even though soil erosion is permitted in the intervening strips of erosion permitting ones.

Mechanical Means of Anti-Erosion: The following are the mechanical erosion control measures that require to be permanently provided so that these measures together with the other biological means of erosion control will effectively function to check and control soil erosion to the minimum possible extent and to promote permanent perservation of the soil and its fertility.

1. Contour Bunding.
2. Contour Terracing,
3. Contour Trenching.
4. Gully Plugging.
5. Construction of reservoirs or ponds.

1. Contour Bunding: Bunding in India is as old as agriculture. And the need for providing permanent and bigger bunds for increasing the productive capacity of the land, was well realised from time immemorial in the State. For, bunding in compartments and bunding along boundaries of drylands are still noticed in many parts of the State. But the age-old method of bunding along boundary of fields and irrespective of slope will not be effective either in conservation of moisture or conservation of soil. The accumulated run off during heavy rains will rush down very quickly and stagnate adjoining the boundary bunds. Since the bunds are laid strictly along the boundary irrespective of slope, the stagnation of water will not be uniform, the height of stagnation being less on the higher level and more in the lower level. Excess run-off will induce overflow at the lower level and as a result the bund will breach at that point, depriving the field of the rainwater as well as productive soil which are so essential for the ever-yielding agriculture. As such the defects of putting up huge section of bund along boundaries is but defective and therefore needs improvements on scientific lines.

Contour bunding is the method of refined way of the age-old practices of bunding; but planned in a systematic and scientific way such that the moisture derived from the rainfall is distributed uniformly all over the field and at the same time soil conservation is made effective. The contour bunds, as its name implies should be laid along contours or as far as possible approach the contours. The spacing of the bunds should be limited in such a way that the intervening area receives the complete and uniform benefits of conservation of mois-

ture. At the same time the soil particles eroded from the top half of the intervening space are deposited over the lower half and convert the area into wide terraces in the long run.

The provision of waste weir to allow overflow of the excess rain-water and to convey it safely down, is found to be necessary, even though this aspect is a controversial problem. Experiences gained in Bombay State where extensive bunding scheme was taken up in various districts, go to show that waste weirs will be quite essential not only to safeguard the bund permanently but also to allow overflow of the surplus rainwater as well as to avoid overstagnation adjoining the bunds the effects of which were found to be very deleterious to the desired crop yield. The Bombay Land Improvement Enquiry Committee set up for enquiring into the defects that led to the numerous breaches of the bunds constructed as Famine Relief Measures and as a regular measure in Bijapur and other areas of the State, have also concluded and remarked that provision of waste weirs will be quite essential for the safety of the bunds.

Largescale bunding along approach contours have been taken up in Coimbatore district of Madras State and the work was being carried out as a Famine Relief measure. About 6,600 acres have so far been contour bunded and from the experience so far gained, it is seen that even in red soil areas waste weirs will be necessary at all vulnerable points where accumulation of excess run off is expected. Since most of the ryots in Coimbatore district were disinclined to adopt curved farming, the alignment of the contour bunds were made in such a way that not only the bunds approach the contour but also the turnings were rectangular, thus providing facilities for square or rectangular farming. So to say it is the compromise between the views of the ryots to have square farming and the scientific method of approaching the contours, that was followed in the Dharapuram Soil Conservation Scheme. It was found during the past seasons that such method of bunding in red soil areas is equally effective in conservation of soil and moisture as also to withstand even very heavy seasonal rains.

Contour Terracing: "TERRACING" is the structural means of interrupting the long slope into several strips and reducing the slope in effect by rendering interruptions to the flow of run off at stages.

Terraces include contour bunding known as "NARROW BASED TERRACING" in American terms, American type of channel terracing, Ridge Terracing and the age-old Bench Terracing.

Narrow based terracing has already been dealt with under Bunding.

Channel Terracing: It is the process of putting up wide and shallow channels along contours and slightly graded if necessary at regular intervals of spacing as decided for the conditions of the land. The excavated soil is spread as a wide and low embankment just adjoining the lower edge of the channels. The capacity of the channel should be capable of holding the excess run off water that will be received from the intervening area; and if the excess water is so much as to require drainage, the slight gradient that is provided to the channel should be such as to carry the excess water slowly and without causing any erosive velocity. This type of terracing will be suitable to soils that are relatively impervious and where reasonably even distribution of rainfall throughout the growing season is experienced. In relatively high rainfall areas where the retention of rainfall in full will be detrimental to the successful crop growth, the slight gradient given will be helpful to drain the excess water and promote better agriculture and better yield.

Channel terracing is advantageous over bunding in the sense that cultivation is possible both on the channel side and on the ridge side and therefore no area will be lost for cultivation.

Ridge Terracing: It is the process by which Ridges are thrown by excavation of wide and shallow channels generally on both sides. These ridges constructed are, as in other cases, along the contours and at regular intervals. The ridge so constructed should be fairly high and the side slopes should be built so flat that the water impounded may spread over a relatively large area on the surface intercepted by these terraces. The aim of ridge terracing is to conserve the maximum possible rainwater and thereby promote conservation of soil indirectly. For areas experiencing low rainfall and for soils that will be capable of absorbing the accumulated run-off quickly this type of terracing will be suitable. These terraces are generally built on lands

with gentle slopes and in areas affected by drought conditions; but it can be constructed even in heavy rainfall areas with sandy soils and gentle slope as experienced in the coastal plains.

Bench Terracing: In fact "terracing" was previously used to typify mostly bench terraces, but the word mostly used by the American Soil Conservationists is in a different sense. In principle terracing is essentially a process of putting up a series of drainage channels across the slope of hill side, their function being to intercept and collect the excess run-off before it attains harmful velocity to erode the soil particles as well as to dispose the excess water slowly to an erosion proof outlet.

Bench terracing is the type that has been followed from ages past and therefore is one of the oldest measures of protecting the land against soil erosion. It is the process of putting up several platforms across the slope and as far as possible along contours separated by vertical drops. The process aims at immediate reduction of the general slope of the country and to intercept the long slope into several strips of platforms. This type of terracing is eminently suitable for very steep lands with very deep soil or with sufficiently deep sub-soil which is capable of regenerating and respond quickly to judicious manuring and management.

The bench terraces may be level, sloping outward or sloping inward according to the conditions of the tract. Level or table top bench terraces or slightly graded inward draining into shallow channels excavated at the rear edge are generally adopted for areas experiencing moderate or heavy rainfall respectively, having absorptive soil and sub-soil. Bench terraces with slope outward is generally used for areas experiencing low rainfall and soil of absorptive character. In all these three kinds, a small wall called "Shoulders" should be provided along the outer edge. The edges of bench terraces should be protected with deep rooted and soil binding grasses or stone walls as the ryot's finances permit. Establishment of grasses has proved to be very effective and economical for the protection of the bench terraces as per experience gained at Ketti of the Nilgiris district where Soil Conservation works with bench terracing as its main feature were executed.

As from experience gained it is found that for Nilgiris conditions 360 man-days will be required for terracing one acre of land on a slope of 25 percent. Bench terracing is also being executed with the help of Tractor with bull-dozer at the Agricultural Research Station, Nanjanad and from the experience so far gained it is found that the tractor is able to do the work equivalent to 200 man-days only to cover one acre of land on a slope of 25 percent. It is also the experience that for Nilgiris conditions, the yield of crop due to disturbance of the soil and mixing up of soil and sub-soil during the process of benching, is not affected because the ryots are generally in the habit of applying heavy doses of chemical fertilisers for successful potato crop. On the other hand there was a net increase in yield of 40 percent during the first season after the completion of the works. In places of poor sub-soil it will be advisable to scrape the soil aside and respread on the surface of the bench terraces formed so that the yield may not be affected much. This method may involve increased expenditure but will compensate the decrease in yield that will be experienced otherwise for successive years in the initial stages till the disturbed layer rejuvenates fully.

Bench terraces are normally constructed either with the vertical interval or the height of benches as constant or with the width of benches as constant. In either case, the height of benches or the width of terraces will vary according to the slope of the land. Apart from the fact of conditions of soil, climate, etc., the limiting factor of the slope in this case is the most important. The greater the slope the lesser will be the width of bench terraces for a constant vertical interval. So also for the constant width of benches the vertical height may vary according to the slope. While constructing the bench terraces, therefore, careful consideration should be given to the fact that the width of bench terraces should be restricted to the minimum on which cultivation and normal agricultural operations would be conveniently carried on. The vertical interval or the height of benches should be restricted according to the depth of soil and sub-soil, their characteristics for regeneration as also the natural angle of repose that will be attained by the type of the soil available at the site.

Contour Trenching: Contour trenching also called "diversion trenches", is the process by which a series of ditches of smaller section are excavated along contours at regular intervals. The excavated soil is thrown as a spoil bank along the lower edge of the trenches. For mild slopes of impermeable soil, such trenches with slight longitudinal gradient will be effective not only to check the velocity of the flow of run off at regular intervals before it could attain an aggressive velocity and carry the excess water safely down to the erosion proof outlet. Such trenches augmented by contour cultivation and other biological control measures will prove effective for soil and moisture conservation on lands with slopes steeper than 1 in 10 and milder than 1 in 6.

Contour trenching at regular intervals is also adopted on steep slopes proposed to be afforested not only for checking the flow of run off and reducing the erosion menaces but also for promoting conservation of the optimum moisture that is required for the seedlings of tree species planted there. For soils poor in fertility and for the tracts experiencing scanty rainfall, contour trenches strictly along contours will be very effective for conservation of moisture as well as soil. The Bombay practice of putting up trenches along contours, interrupting the same at every 200 feet length and dibbling the seeds or planting the seedlings along the edges after re-filling the trenches half diagonally, is found to be very effective and efficient for poor soil conditions. Dibbling on the spoil bank is also practised in some parts of India like Hyderabad and this is found beneficial where soil conditions are fair.

Contour trenching at regular intervals is also practised more as a moisture conservation measure than as a soil conservation one on lands put to pasturage. From the experiments abroad it is understood that by the provision of the contour trenches in pasture lands or grazing ground, the growth of pasturage is stimulated due to the increased moisture conserved and supplied to the intervening plots and the yield of pasturage is increased by about 25 percent of the normal yield.

Principles of Terrace Design: As already stated the purpose of providing terraces is not only to prevent soil erosion and conserve soil

but also to facilitate conservation of the optimum moisture so essential for the plant growth uniformly. In scanty rainfall areas the purpose will be to conserve the maximum possible rains whereas in a heavy rainfall area the purpose will be to drain the surplus water safely without causing soil erosion. Where conservation of the maximum possible rainwater is the criterion, the terraces must be laid along contour lines or level lines and this type of terraces is called "LEVEL TERRACES". Where disposal of the excess water is the criteria, the terraces are provided with slight longitudinal gradients which will not only induce but also regulate the flow of accumulated water without causing erosive momentum and drain it through erosion proof outlets. This type of terrace is called GRADED TERRACES. In very heavy rainfall areas with impermeable soil conditions the excess water will have to be drained very quickly and for this purpose generally a uniform gradient lengthwise is provided. Such type of terraces are said to be uniformly graded. If the amount of rainfall and soil conditions are favourable for facilitating absorption of more rainwater and if at the same time certain portions of the rainwater is still to be drained off, the gradients lengthwise are varied according to the needs of the amount of conservation and disposal of rainwater. Such terraces are said to be VARIABLY GRADED. The principle involved in the selection of gradients is either to increase or decrease the time of concentration according to the porosity of the soils, the crops cultivated and other conditions, such that the time allowed for the soil to absorb the moisture may be less or more according to the need.

The selection of the optimum spacing is another important factor to be considered in the design of terraces and for this the porosity of the soil, sub-soil, water requirements of the crops, climate and other conditions are points to be taken into consideration in addition to the slope of the land. With the other conditions similar, the spacing of the terraces will vary according to the slope. The spacing so designed should be such that the velocity of the run-off water is checked, retarded and kept below the critical velocity between two adjacent terraces. At the same time the zone of stagnation and the zone of Saturation which is influenced by the seepage water from through the stagnation zone, should meet and the moisture to be

conserved is spread uniformly between the two adjacent terraces. The normal spacing that is followed for our conditions is 3 feet fall in level or 300 feet horizontal distance for black soil areas and 150 feet horizontal distance for red soil areas which ever is less. But the spacing will vary with the varying conditions of the tract viz. rainfall, soil type, crops grown, climate etc. The section of the terrace should be such that it would be capable of resisting the momentum of the surface run off and at the same time strong and stable, having the line of resultant force falling within the middle third of the base. The saturation gradient *i. e.*, the level at which the terraces will be saturated with the seepage moisture due to the stagnation of the rain-water at the higher side, should pass through within the safe limit of the width of base.

Gully Plugging: The final and the most disastrous stage is the Gully Erosion which deprives the land of the huge amount of precious soil, renders the land into unnecessary and inconvenient fragments making agriculture difficult or impossible, and drains off the little amount of moisture that is received due to the rains precipitated on the adjoining mounds under cultivation. The formation of gaping gullies is the danger signal for the utter destruction of the land and therefore immediate attention will be quite essential to plug the gullies systematically.

Gaping gullies never occur single and many numerous and meandering finger gullies as well as small gullies draining into the valley portion result in the formation of a common and gaping gully. While attempting, therefore, for plugging gullies it should be the aim to completely eliminate all the subsidiary gully formation which form tributary to the major gully and allow the major gully to function to drain the excess water safely. The major gully thus allowed should be trained to attain a smooth and advantageous course and the further formation of erosion of its bed and sides should be checked and controlled by planting vegetational cover crops or trees. The sides of these major gullies should be eased and planted with deep rooted and soil binding grasses. If such major gullies had already

been cut badly, action should be taken to plug the same to get the required depth and width only, the normal way for the water to drain through being allowed thereafter.

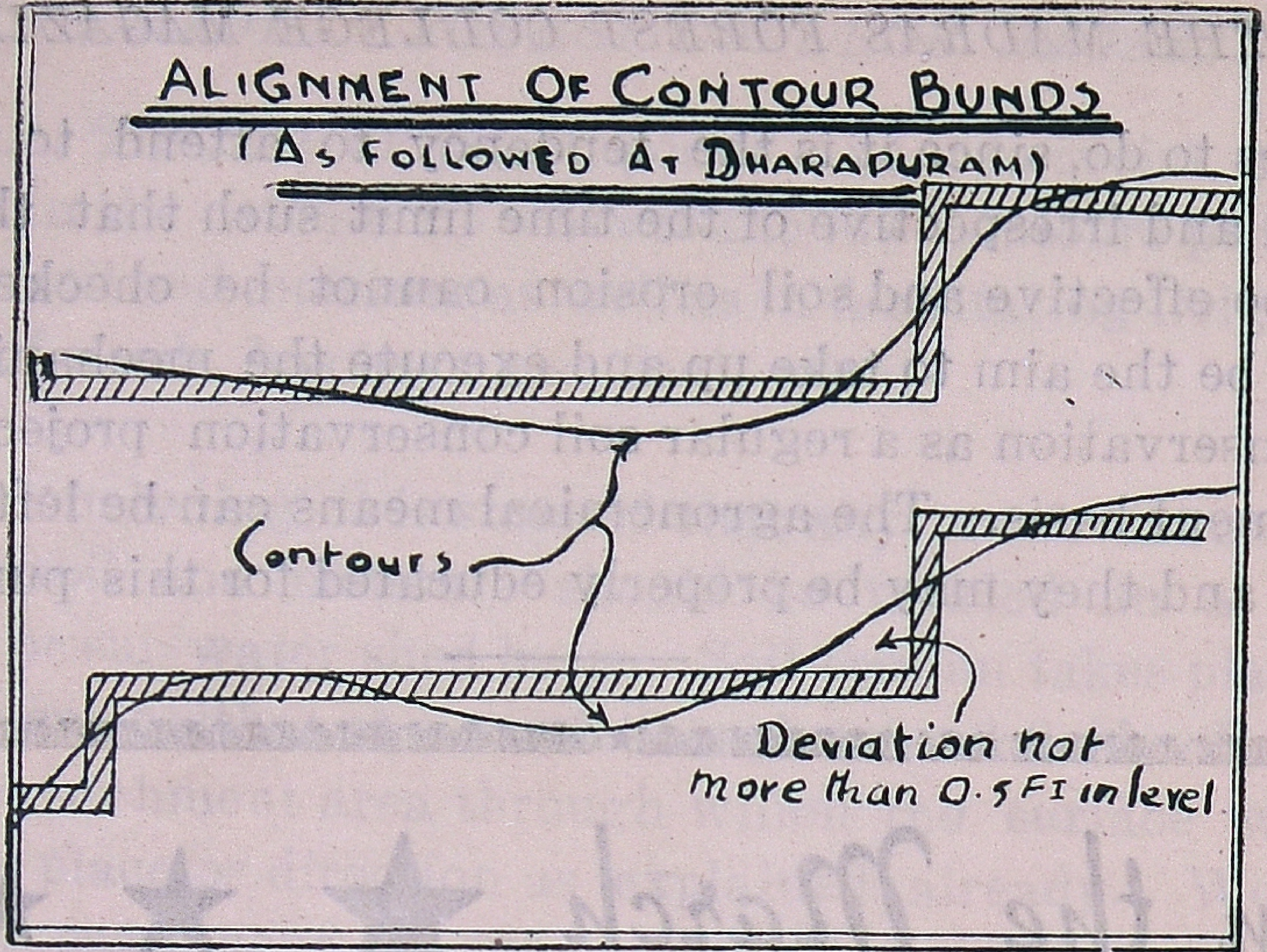
For plugging and eliminating gullies, it will be necessary to provide check dams of either brushwood or stone, or even permanent structures across the course of the gully and at critical intervals. The construction of such dams should start from the very source of the gully and maintained by increasing the height of dams periodically and systematically till the complete gully is eliminated. The spacing of the check dams should be such that they may give resistance to flowing water through the gullies before the water attains the erosive velocity and reduce the same to the minimum so that the silt that is being carried through may be deposited at the check dams and level the space between check dams in due course. Increasing the height of the check dams systematically soon after the silting takes place to the top level of the lower check dams and maintaining the same in a systematic manner commencing from the top-most dam will facilitate plugging and effective elimination of the gullies in course of years without having to scrape the soil from the adjoining mounds to level and plug the gullies.

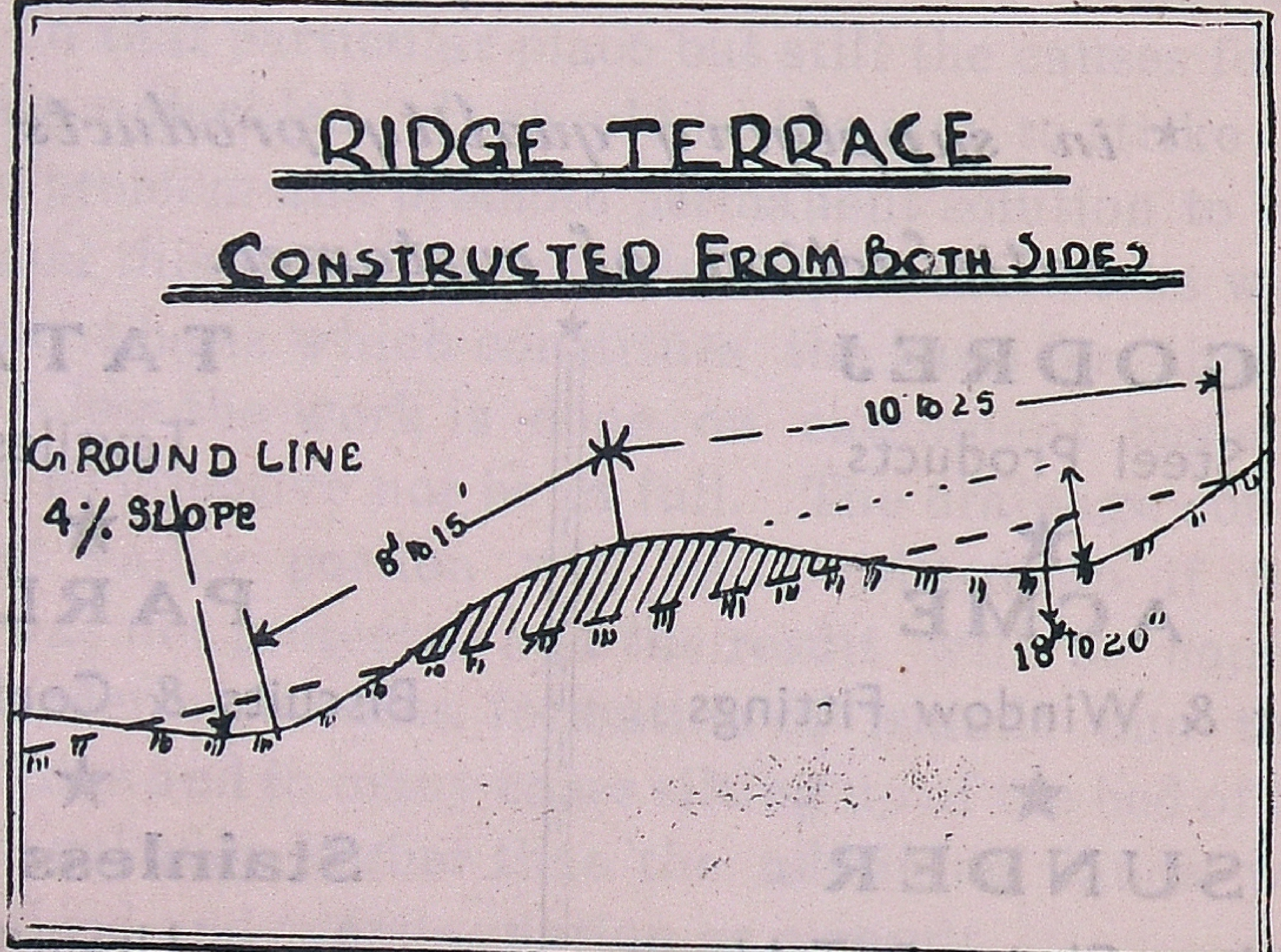
It should also be borne in mind that as far as possible the volume of water that will rush through to the gullies will have to be reduced as much as possible; and for this purpose diversion trenches with suitable grades may be provided at the head of the gully so that a portion of the run off water may be diverted away from the gullies and the volume of flow within the gully, reduced proportionately.

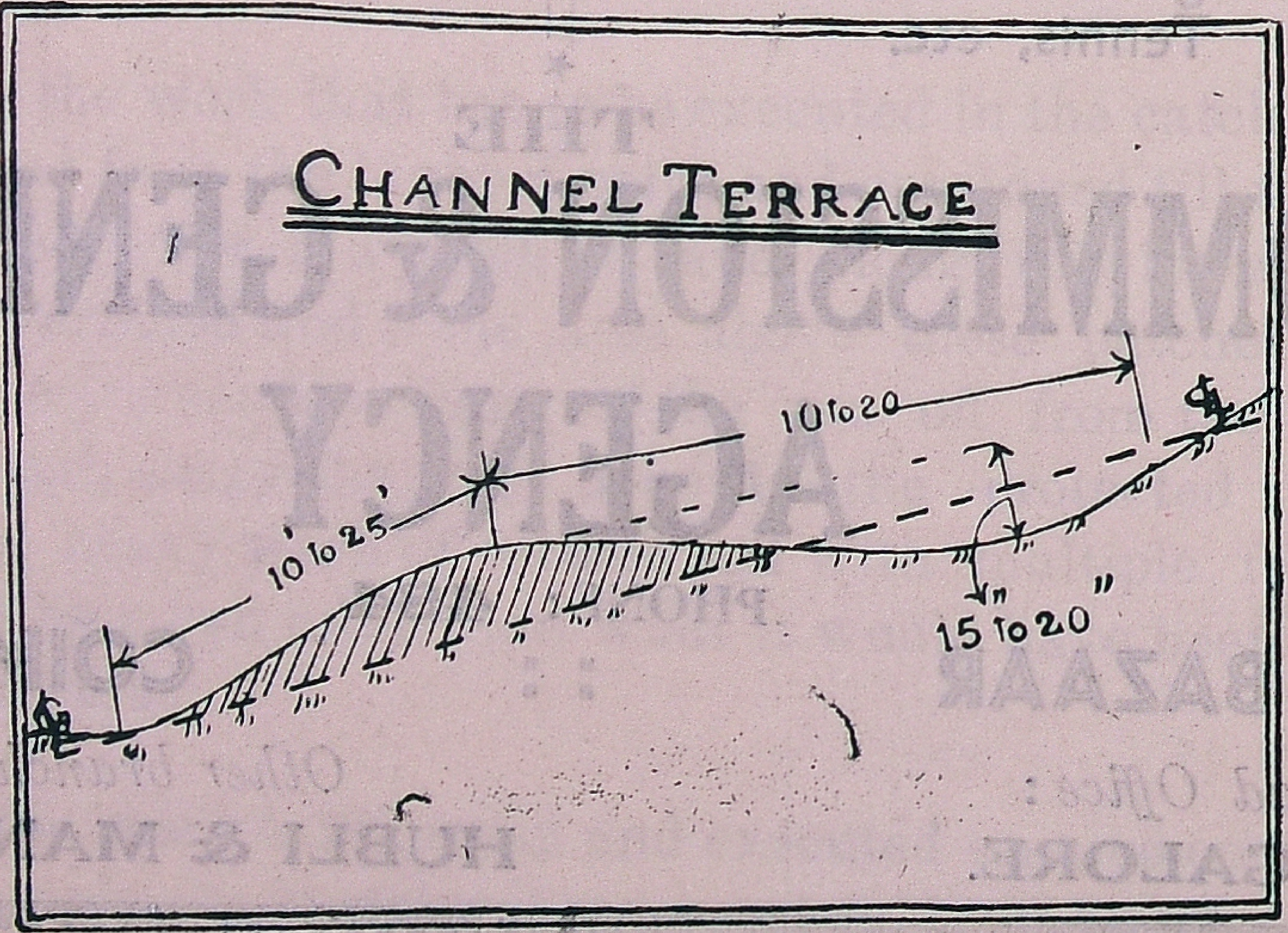
Small ponds and reservoirs : In addition to the various soil conservation measures, it will be beneficial to form small ponds and reser_ voirs within the catchment wherever contours permit and connect them in chains. These ponds and reservoirs, having capacity to hold an appreciable portion of the run off, will enable holding the excess run off water before the same attains erosive power and erodes the top soil. The water collected in the ponds seeps through sub-soil, adds to the underground springs and strengthens the same. They enable to increase the general water table and thereby the facility for irri-

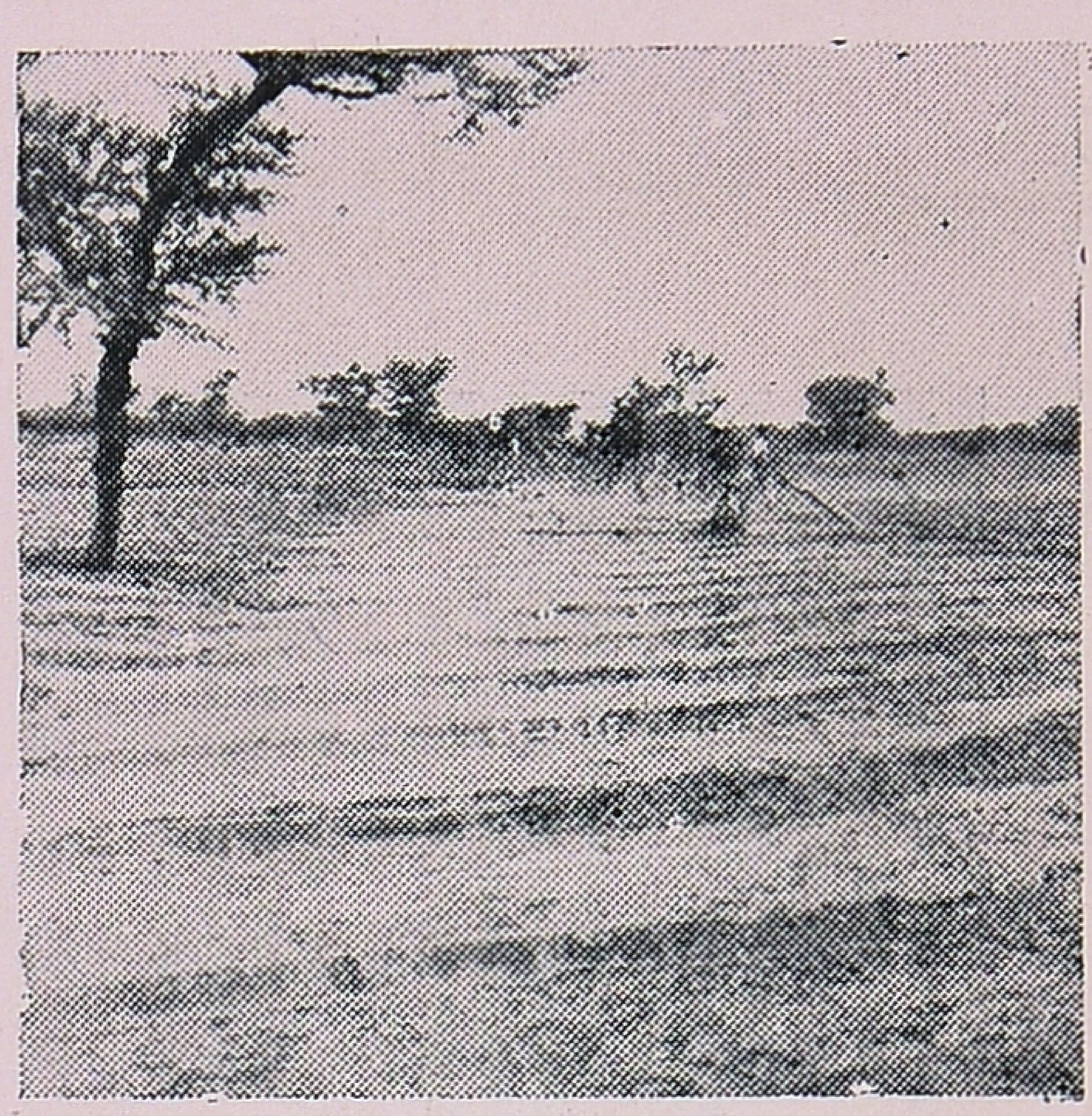
gation. The stagnated water in these ponds and reservoirs can be utilised for irrigating the crops in the adjoining lands during the off season, or when the monsoon is erratic and ill-distributed.

Summary : This article deals with the principles of engineering aspects of soil erosion and those involved in the design of the various control measures including mechanical means of anti-erosion. Climate, topography, rainfall, soil type and surface cover are the few of the many causes of soil erosion and the first three are difficult to be eliminated but could be harnessed by proper utilisation and management. The amount of rainfall, its intensity and distribution, the location of the catchment, its size and shape, the nature of topography and slope of the country and the soil and surface conditions are all the factors that have great influence in inducing soil erosion menaces. Of the various control measures to counter-act the erosion forces, the natural protection by the vegetative cover, grass or trees is the best, but cultivation by breaking open certain lands under natural cover is but essential to meet the various needs of Man. As far as possible the lands should be protected against soil erosion menaces by adopting the one or the other of the various agronomical practices of anti-erosion. When it is not possible to control the soil erosion by such biological means alone, mechanical means like contour bunds, contour terraces, contour trenches, gully plugging and construction of reservoirs and ponds should be adopted together with the other biological means. The general principles of engineering involved in the various control measures are (i) To retard the velocity of the run off; (ii) to increase the time of concentration and thus promote absorption and power of holding of more water by the soil. The technique underlying the construction of various terraces including contour bunds and bench terraces have been dealt with in brief. The advantages of contour trenches for cultivated lands on medium slopes and for steep lands to be afforested together with the principles underlying the selection of the space, section and gradient of these trenches have also been dealt with. The important and broad principles on which the terraces have to be designed to meet the various needs of the land, the topography, rainfall, soil, climate, etc., and the importance of plugging, controlling and eliminating the most dangerous gully erosion for the benefit of agriculture and preservation of the soil permanently have also been

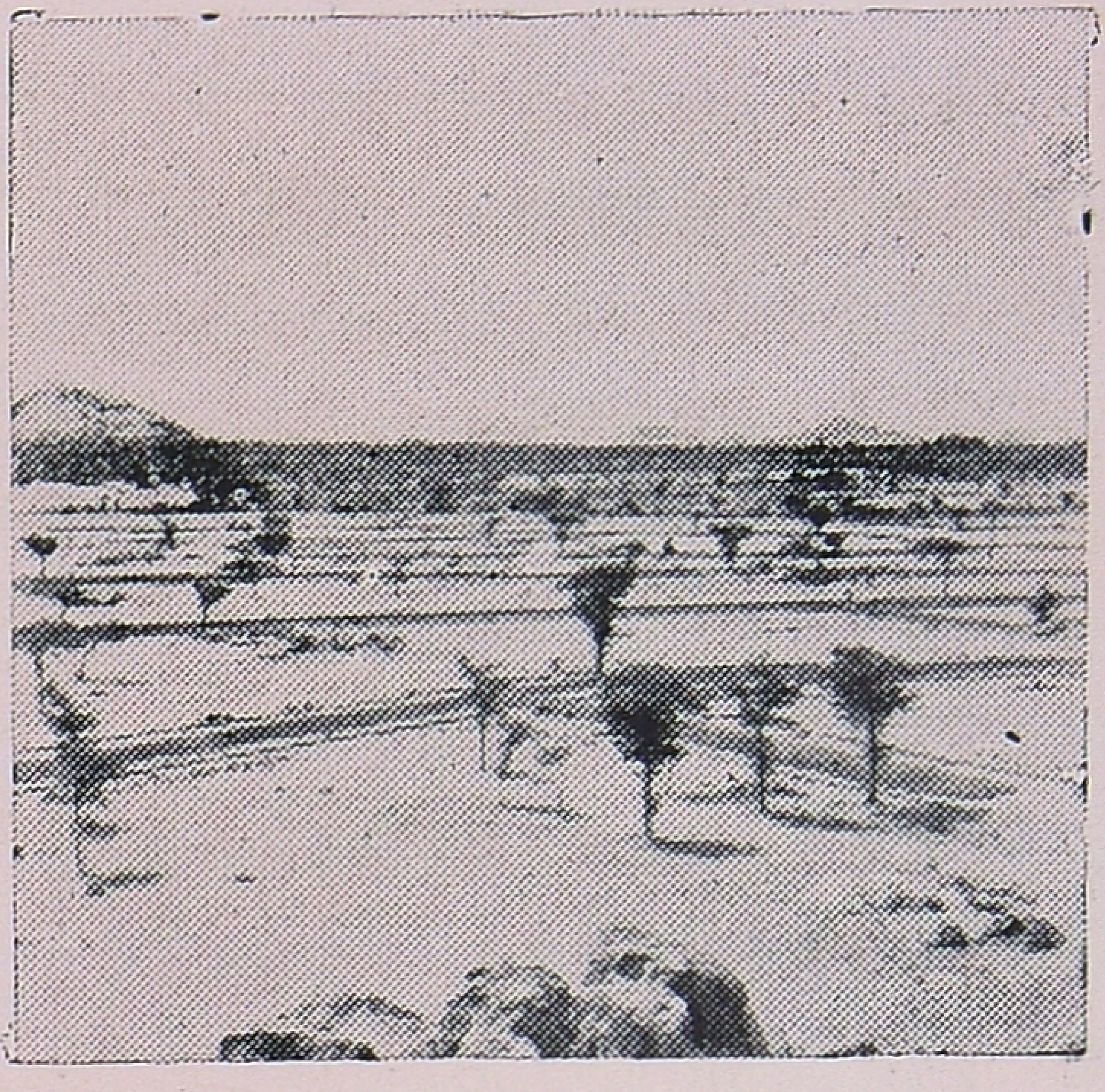

ALIGNMENT OF CONTOUR BUNDS
(AS FOLLOWED AT DHARAPURAM)
Contours
Deviation not
more than 0.5 FT in level


RIDGE TERRACE
CONSTRUCTED FROM BOTH SIDES
GROUND LINE
4% SLOPE
8' to 15'
10' to 25'
18" to 20"


CHANNEL TERRACE
10 to 25'
10' to 20'
15" to 20"

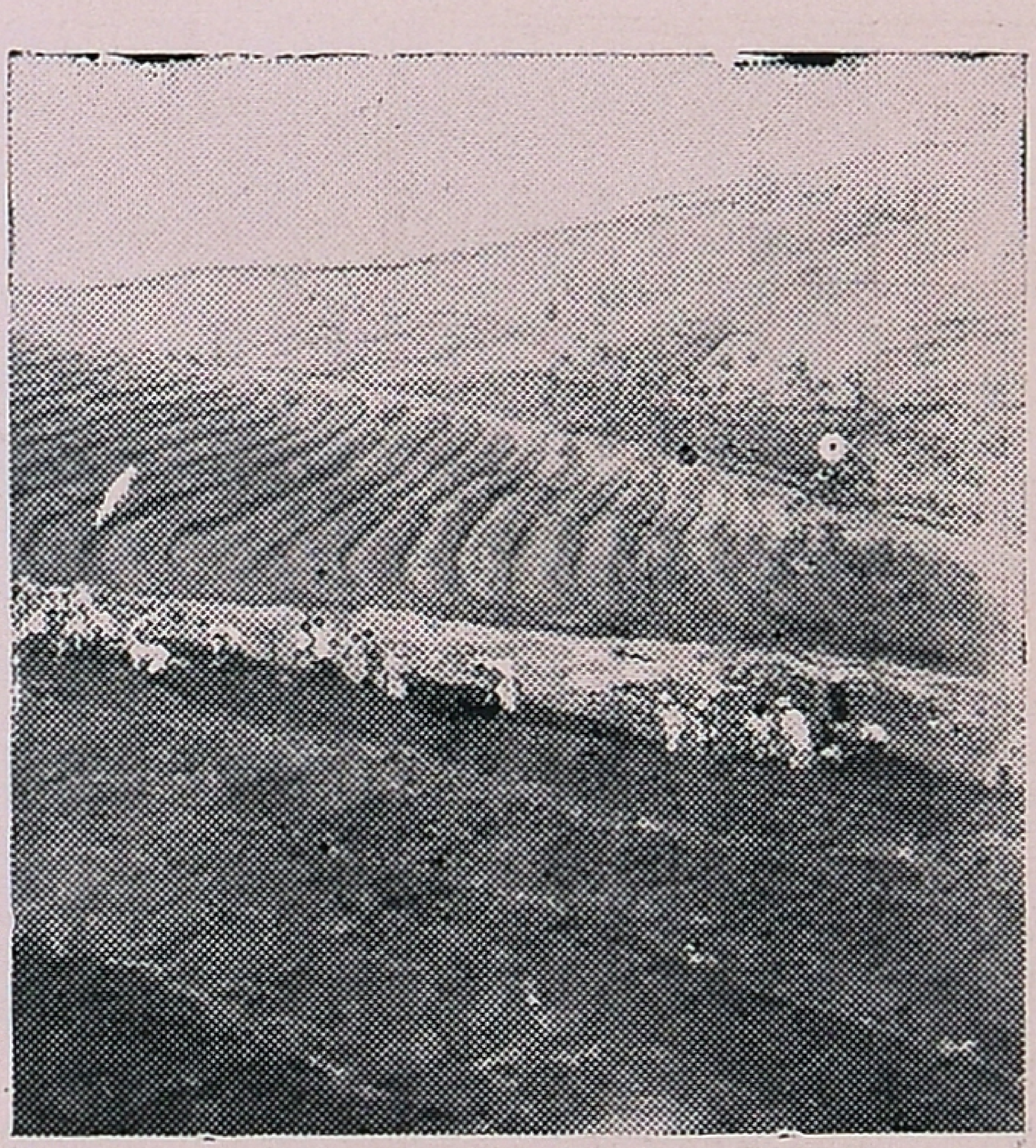


1. Sheet erosion caused by Water and Wind at Dharapuram.



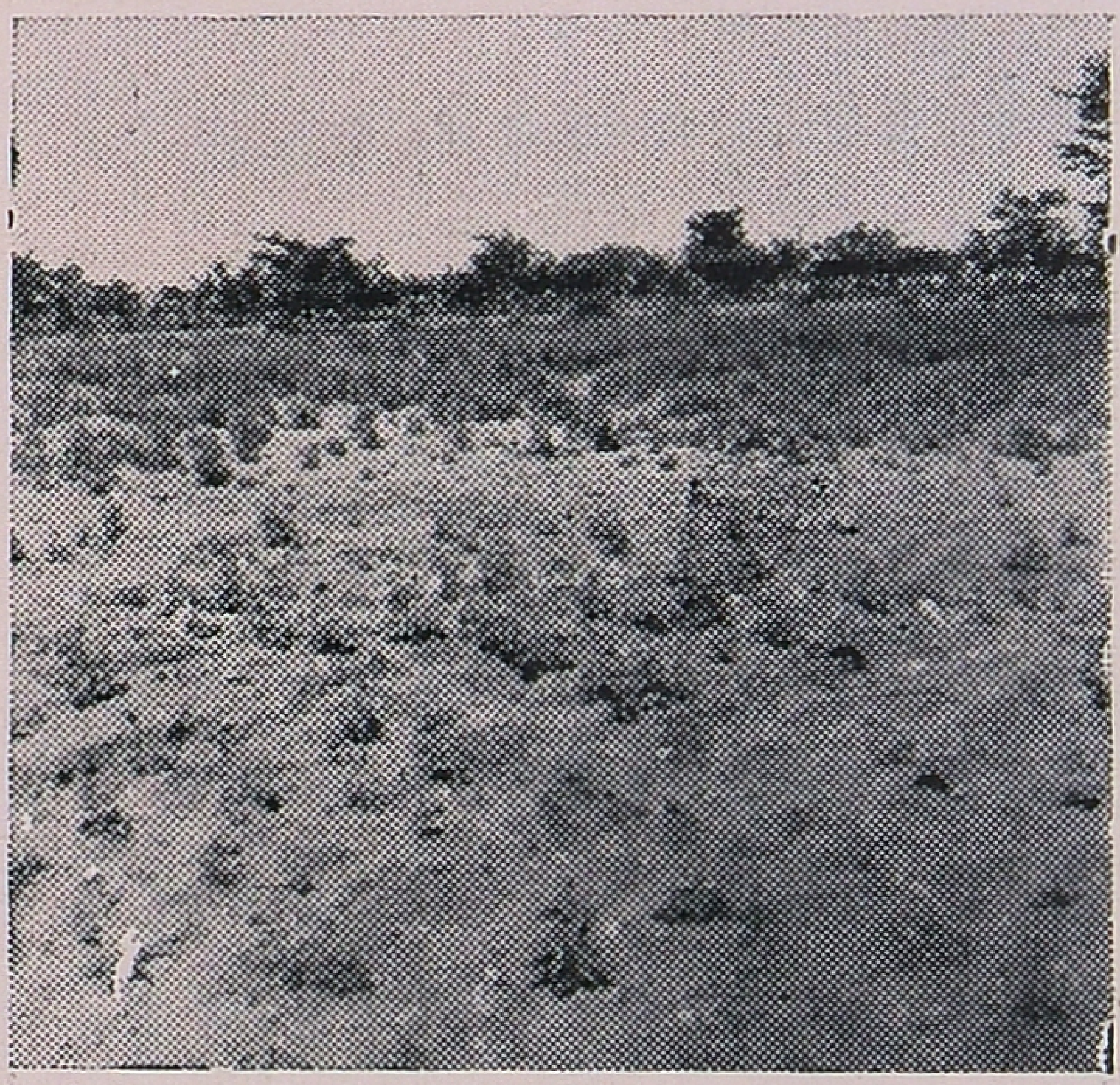
3. Contour Bunding at Dharapuram.

2
Rill Erosion Developing into Gullies.



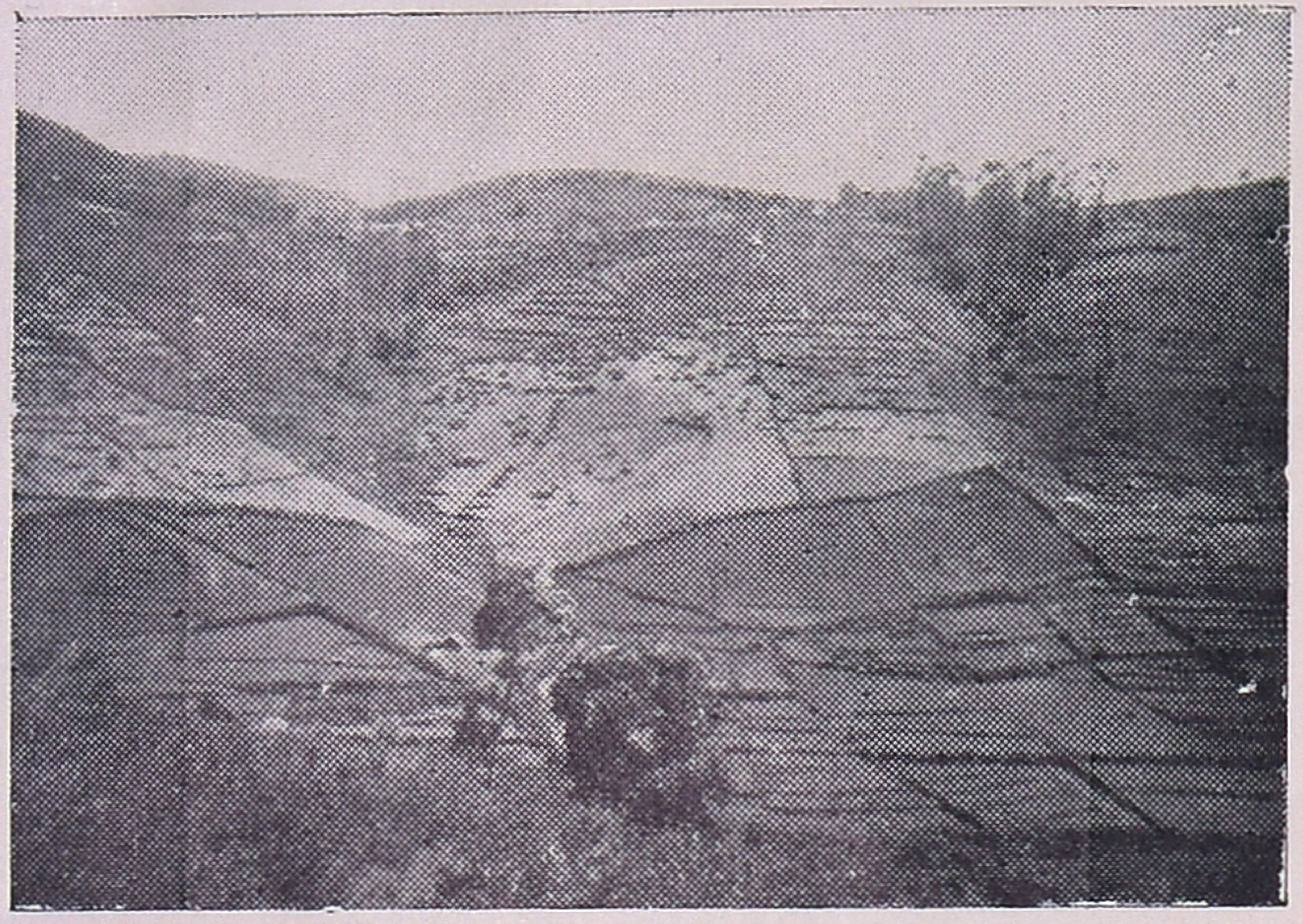
4. Bench Terracing - Steep Slope.

Photos 1 to 4 by Sri S. Narayanaswamy.



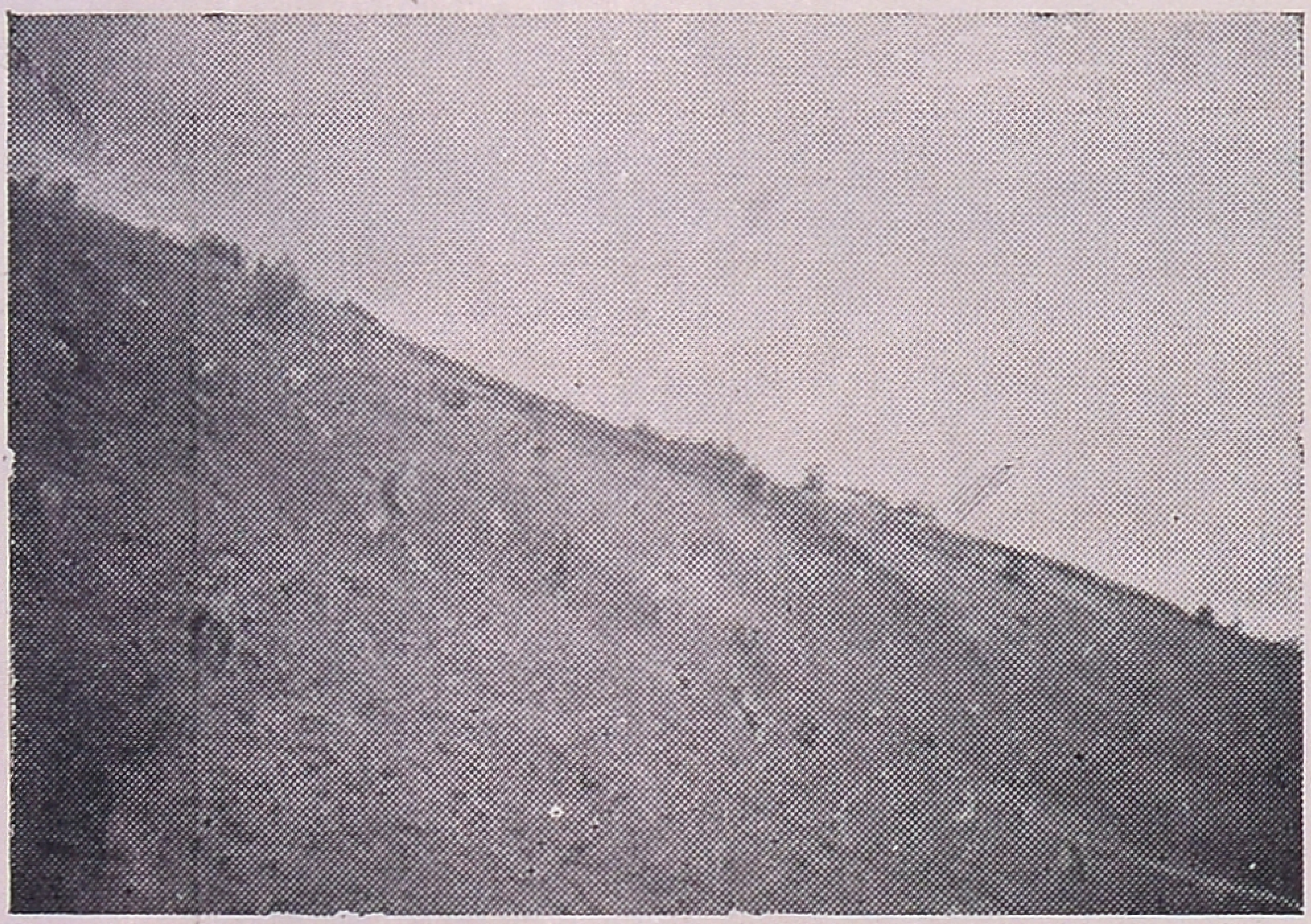
Wind Erosion at Dharapuram.

Photo by Sri B. M. Lakshmipathy.

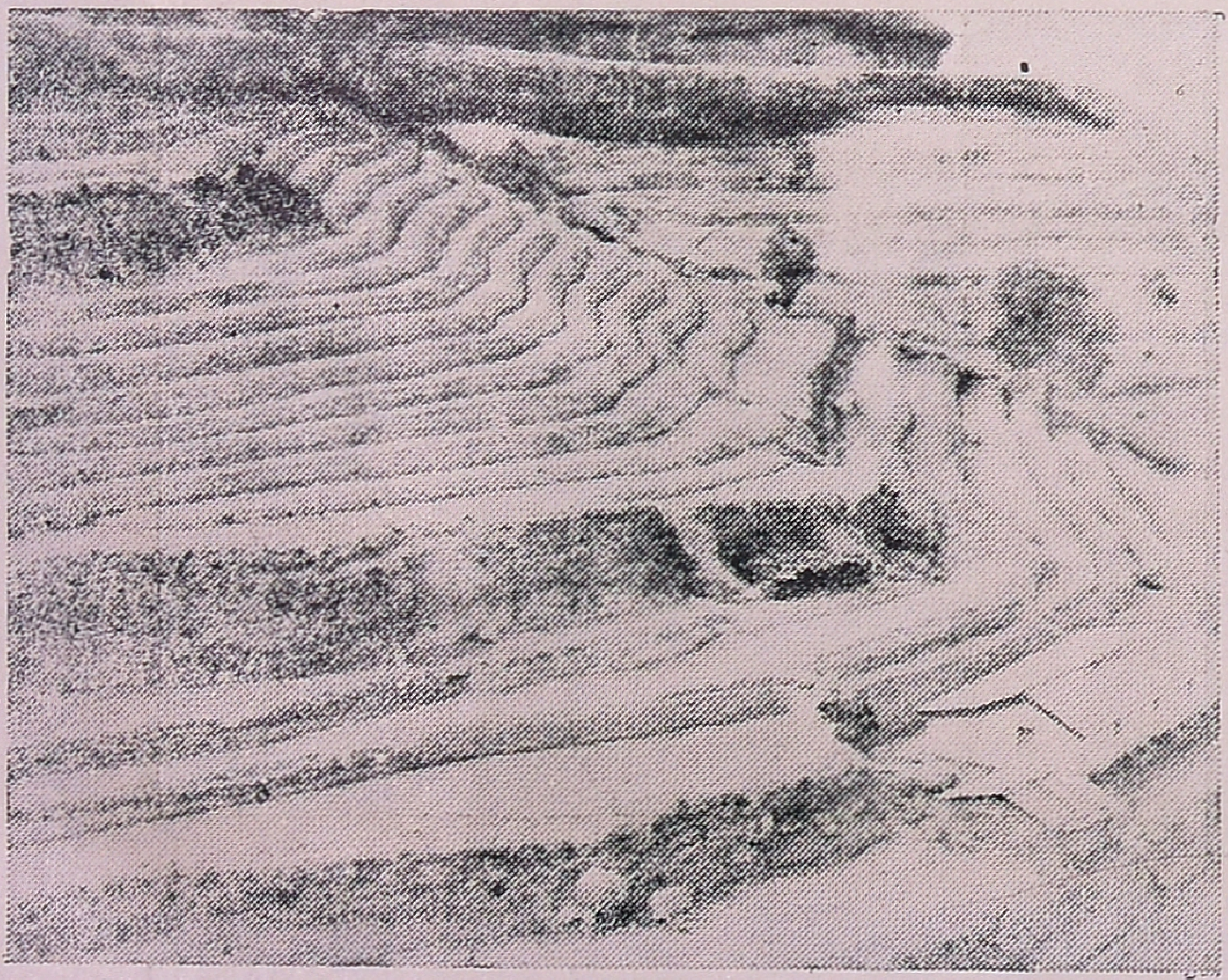


Irregular Cultivation on the Nilgiris.

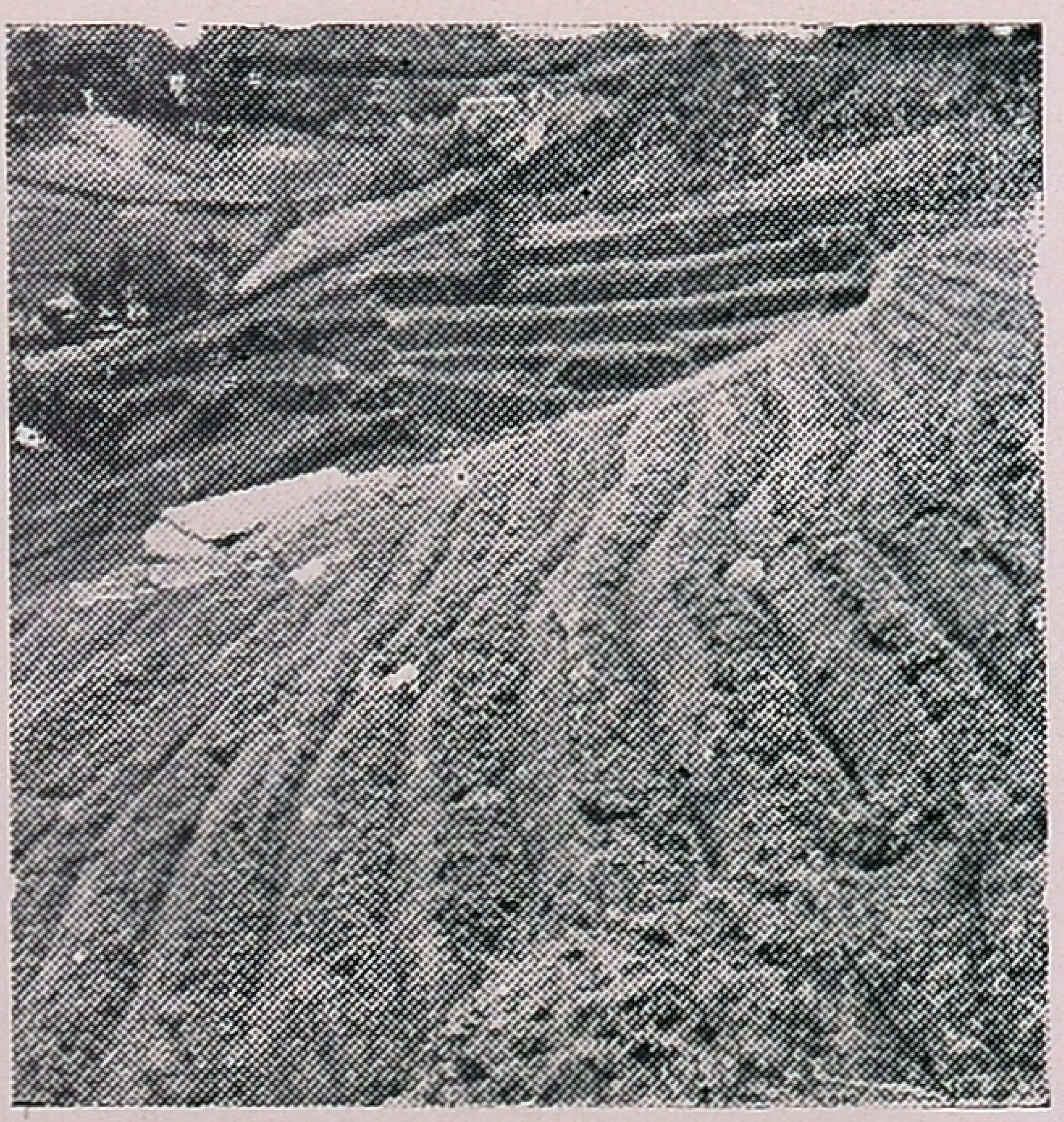
Sparse Growth of Potato
Unprotected Area.



Deforestation of Steep Slopes for Cultivation.



Bench Terracing - Steep Lands.



Luxuriant Growth of Potato
in Terraced Area.

Photos by: Sri B. M. Lakshmipathy

Soil Conservation and Land Management.

By **B. M. Lakshmipathy,** B. E., M. E., M. R. A. S. E.,
Hqrs. Dy. Director of Agre., (Engineering).

Introduction. All the vital living necessities of human life excepting perhaps light and air, are derived from the "SOIL" which is the basic factor for the very existence of humanity. Food to eat, clothes to wear and materials for shelter are all obtained by the varied and judicious utilisation of the soil and its fertility. Soil resources - NATURE'S most precious gifts - should therefore be not only protected for permanent and stable agriculture but also preserved systematically for meeting the other demands of life on the land both human and animal.

Soil erosion. The natural process of weathering and the denudation of the soil in the normal manner and in the slow natural stages is in fact not indispensable, in the process of soil formation whereby the parent rock materials is continuously disintegrated by the slow action of wind and water until suitable top layers for plant growth are created. The natural process by which a stable static equlibrium between soil denunation and soil formation is created, is called "GEOLOGICAL EROSION". When such stable equilibrium is disturbed by breaking open the land for farms and fields and cultivating the same without due regard to water and land capabilities, "ACCELERATED LAND EROSION" is induced. While "Geological erosion" is necessary for the survival of all kinds of life, man-made "Accelerated erosion" is the cause for the gradual deterioration of soil fertility as would be seen from the various examples of barren deserts in a number of countries.

The earliest symptoms noticed on land forced for exploitative cultivation will be the loss of the inherent fertility of the soil and its diminished productive capacity. Such depleted soil is not stable and due to the lack of stability in the soil particles, the gradual movement of the productive layers in thin and uniform layers take place during the next stage. Such soil loss is called "Sheet erosion". Generally,

it is only the top few inches that are fertile, stable, and absorbant. Sheet erosion removes these absorbant layers of soil, exposing the less absorbant, less stable and less fertile sub-soil below. The natural loss of the productive soil layers is uniform and as the fall in fertility is very slow in course of years, the harmful consequences of "Sheet erosion" in the initial stages are generally ignored by ryots who usually attribute such consequences to the passing vagaries of rainfall and climatic conditions. Sheet erosion is thus usually neglected and not realised until it becomes extensive over a large area and develops "rills" and even deepening "gullies". The damages of soil erosion though felt in slow degrees to start with, will vary very greatly in successive stages in geometrical progression. The difficulties of management and protection will increase tremendously with the development of the serious stages of soil erosion.

In addition to the ravages by water erosion, wind also plays its damaging part in accelerating soil erosion. The absence of protective cover, the low fertility of the soil which is unstable due to lack of cohesion between soil particles and the long spell of drought conditions which aids desiccation of the fine particles of top soil, are the chief causes of "Wind erosion". If the country is broad, flat and slightly undulating, the soil particles blown by wind are carried away unhindered also damaging crops, if any, grown within the area. Where water erosion is not serious due to conditions of land, climate and rainfall, wind erosion removes away the productive soil to waste, When the force of the wind loses its velocity, the heavier particles are deposited in drifts or dunes at the place; and the finer particles are carried still farther away and deposited. The deposition of the coarser particles in drifts or dunes engulfs cultivated lands and renders cultivation difficult, if not even impossible at a later stage. The finer and fertile particles deposited at other places are mostly washed away easily by the subsequent rains and carried to waste. "Wind erosion" is deleterious to the agricultural lands and needs careful and coordinated attention along with sheet erosion.

Erosion control : The immediate results of the action of the surface run off or the violent action of the winds will be the displacement of fertile and absorptive soil particles. Therefore the basic factor

that has to be considered before tackling and exposed lands affected by erosion menances, will be to control the conditions on the surface to retain the soil moisture nearest to the surface and to create an ecological balance between soil displacement, movement and soil conservation. All soil conservation measures like contour cultivation, basin listing, rotational cropping, strip cropping, manuring, forming compartments with small bunds, providing permanent embankments, terracing, diversion ditches, detention of storage water in small ponds or reservoirs are designed mainly to achieve the above object according to the factors requiring attention.

Among the various factors that influence soil erosion the most important is the rainfall. The problem arises both out of scarcity of seasonal rains and from uncontrollable and heavy precipitations. Scarcity deprives land of cultivated crops and natural vegetation and thereby depletes it of the protective cover. Continued drought destroys also the cohesive property of the soil and as a result even slight wind or run off water induces heavy soil erosion. Due to constant desiccation wind and water erosion, the depth of the productive and absorptive soil is reduced and thereby the capacity to retain and to supply back to the plants the rainwater, is adversely affected. The soil will thus not be able to beneficially utilise the little amount of rainfall that may be precipitated and a greater portion will run off to waste, The conditions resulting from continuous drought will be accelerated and may in years lead to distress and famine as was recently the case in some parts of this country.

The heavy rainfall precipitated on the unprotected fields induces heavy surface run-off which attaining increased momentum during its march downwards also tears away the surface layers of the land and carries large amounts of soil. A greater portion of rainwater also runs usually to waste, since the sloping lands devoid of protective vegetation does not allow sufficient time for the water to percolate through and be absorbed by the lower layers.

The other influencing factor in soil erosion is the type of soil, its physical properties like texture and structure and the amount of run off. If the soil is loose and open and its physical condition such as

to absorb and hold more rainwater the amount of run-off will be reduced proportionately thereby arresting the erosive capacity of the surface run-off. The " Dispersion Ratio " which measures the readiness with which the soil particles go into suspension also denotes the driable nature of the soil and its susceptibility to erosion.

The sub-soil profile has also a relative bearing on the erosive power of the run-off. If the entire profile is uniform in texture and allows steady percolation after saturation, there will be greater chances of a greater portion of the rainfall soaking in with a reduction in the run-off.

The nature of the topography is yet another important factor influencing soil erosion. If the lands in question are steep and undulating, the run-off water will gain more velocity and power to tear the soil layers and aid accelerated erosion. The steeper the lands and more undulating the terrain, the lesser will be the time taken for the surface water to reach the valley bottom, rivulet, river or drainage course with a considerably diminished opportunity for the soil to absorb and hold the rain.

The climatic condition is also another cause influencing erosion; the dry climate reduces the resisting power of the soil against erosion whereas a humid climate increases the stability of the same. The surface condition also has an influence on erosion losses, Vegetative cover like grasses, trees, bushes etc. will give protection to the lands against the direct beat of the rains, resistance through their stems to the flowing run off and soil binding effect through the net work of their root system. The reverse is the process on lands devoid of such vegetative cover.

The immediate aim in planning any systematic soil conservation is to control the transportation of soil particles to waste by agronomi, cal means. The common objects of all conservation measures are (1) to allow time to the soil to absorb the optimum moisture from the run off water and (2) to reduce the amount of run-off water, thereby reducing the erosive power of the same. The moisture is retained nearest to the surface of the land so that the soil particles retaining water

may be stable against soil erosion. The texture and structure of the soil is improved by judicious manuring so that the soil particles may be more readily absorptive to rain and reduce run-off. By a careful combination of the various agronomical means, it is feasible to check and control soil erosion menaces on lands with mild slopes not exceeding 3% (*i. e.* 3 feet fall in level in horizontal distance of 100 feet.) For slopes exceeding that limit, other structural means involving engineering aids should be provided.

But, there is also a practical limit upto which provision of such structural modifications will be economical and efficient. Bench terracing of the land by contour platforms at regular intervals is a measure suitable for steep lands having more than 12% slope. This same item becomes prohibitively costly and can only form inconveniently narrow terraces on steep slopes, with more than 25% gradient. Lands steeper than 25% gradient should not, therefore be brought under cultivation of annual or seasonal crops. They should be put under permanent tree or grass or vegetative cover. Growing trees of economic value or grasses or pereunial and economic plants will not only fetch a fair revenue to the owner but will also check soil erosion and preserve the land permanently. The yield will be everlasting and the intrinsic value of the land will not dwindle as when brought under regular seasonal cultivation.

Soil preservation. The next complementary aim requiring important consideration is the permanent preservation of the soil protected against erosion damages. Agriculture annual or biennial or semi-permanent will mean conversion of soil fertility to reap the products that are necessary for food and other necessities of life. But, generally the crop residues are not returned back to the soil to replace the lost fertility. There are certain crops which completely depend upon soil and moisture for growth and which deplete the soil fertility and there are other crops which take in nitrogen requirements from the atmosphere and fix the same in the soil to enrich it. If a soil depleting crop is grown on a land, a soil ameliorating one should always follow applying suitable manures also with sufficient organic materials. Strip cropping indirectly amounts to rotational cropping

or mixed cropping and tends to balance the fertility loss due to cultivation of erosion permitting or soil depleting crops.

Improved agronomical practices and soil conservation are interdependant and inseparable. Without proper soil conservation, scientific agronomical practices, will not give the desired results and that on a permanent basis.

Soil Conservation in the State. Soil erosion in Madras State (Residuary State) has become important only in the last two years. Lateritic soils of the Malabar, Coimbatore and Nilgiris districts, the loamy and red soils and the black soils of other districts have begun to show signs of erosion and loss of soil fertility. Barren hillocks with deep and meandering gullies and rill and gully erosion on the sloping lands are also seen developing. New areas have been deforested and opened for cultivation of tuber and other crops on the Nilgiris, Kodaikanal, Anamalais, Shevroys and other hills and plains. Intensive cultivation on the hills has particularly accelerated soil erosion which is now spectacularly visible to every farmer after every heavy shower. Soils and even seeds of tuber crops like potato can be actually seen rolling down with the run-off water and it will not be untrue, if it is said that the cultivators had to often chase the rolling potato seeds for collection and replanting, of course, without minding the loss of the productive soil and fertility. But today, the soil erosion menaces in this district have grown to such an extent that it has become a major problem. Reduction of yield, soil erosion menaces, silting up of irrigation tanks and hindrance to irrigation facilities, continued drought and failure of crops and lowering of water table are now frequently mentioned and the losses caused are felt more than ever before. Soil Conservation, improved agriculture, sustained crop production and maximising yields have become outstanding features of any agricultural plan.

On the advice of the soil conservation Experts, Government of India, a State Soil Conservation Board was constituted for this State in the year 1951 to initiate, co-ordinate and render help and advice in the execution of soil conservation schemes in the State. A district

Soil Conservation Board for the Nilgiris was similarly functioning for concentrating attention on the Nilgiris and its outer boundaries. The enactment of the Madras Land Improvement Schemes (contour bunding and contour trenching) Act was passed during 1949, empowering the State Government to select and execute soil conservation measures in any catchment or sub-catchment. A soil conservation scheme with bench terracing as its main feature was sanctioned and executed as a demonstration centre on an area of about 300 acres in Ketti Valley in the Nilgiris. A scheme for soil conservation with contour bunding as its main feature was sanctioned for execution as a Famine Relief Measure at Mulanur Firka of Dharapuram Taluk in Coimbatore District and so far about 6,600 acres have been covered.

The work done so far on soil conservation in Madras State is negligible compared to the vast problem facing the State. Proposals are on hand to tackle every one of the affected districts of the State, as also to open a Soil Conservation Research Centre at the Agricultural Research Station, Nanjanad. Researches already conducted on soil and run-off losses at Hagari and at the Agricultural Research Station, Nanjanad have proved beyond doubt the collossal loss of productive soil every year and the loss of rain water as run-off. It is proposed to concentrate more on the execution of work in the sanctioned areas and take steps to protect as much area as possible and practicable every year against erosion menaces.

Conservation measures give permanent protection to the sloping lands against soil erosion in addition to permanent improvements to the lands and increasing its capital value. The soil arrested from being washed away is preserved on a permanent basis and by judicious manuring and improved cultivation crop production is increased by 25% nett over the normal yield per acre. Conservation of optimum moisture and water retentive capacity of the soil are also ensured. The increased permeability of the soil and the percolation of a greater amount of rain water will finally replenish the underground sources. The general water table will in due course rise up and lead to better facilities for irrigation and drinking. The silt accretions in the irrigation tanks and reservoirs will also be prevented and controlled.

Summary. Soil is the most precious and important one for the very existence of man and other life and therefore its preservation is of utmost necessity. While Nature's "geological erosion" stands to benefit the land, the other types of accelerated erosion are very dangerous and require to be checked and controlled to the fullest possible extent. The erosion control measures should be capable of counter-acting the dangers of rainfall, climate, topography, soil and surface conditions etc, and not only check soil erosion but promote permanent preservation of soil fertility. The work done on soil conservation so far in the Madras State is very little, covering 300 acres in the Nilgiris and about 6,600 acres in Coimbatore District. Proposals are on hand for research on soil conservation at the Agricultural Research Station, Nanjanad in the Nilgiris and for execution of soil conservation works in most of the affected districts of the State.

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8/23, AVANASHI ROAD,
COIMBATORE.

Soil Conservation and Land management with particular reference to Podu Cultivation in the Agency Areas of Andhra State.

By **T. C. Kesava Rao**, B. A., (D. D. R.)
Kakinada.

Soil erosion is the loosening of the soil from the parent rock and the transportation of the soil material from one place to another, through the agency of wind or water in motion. The soil is the uppermost weathered and disintegrated layer of the earth's crust having a depth of 6 to 12 inches. This thin layer of soil resting on a rocky core is responsible for all plant growth. It supports all animal and human life. Therefore it is of paramount importance to us to protect this layer of soil and to see that its fertility is maintained.

History is replete with instances where highly developed civilizations and countries were reduced to mere barren wastes by a neglect on their part of this problem of soil conservation and land management. Mesopotamia and Greece afford but two examples as to how bad land management can affect the posterity of a country. Agriculture developed on the very fertile soils brought down by rivers from the hills and deposited on the plains. The hills were mostly covered by thick forest. But, as cities sprang up and demands for timber, firewood and extension of cultivation told upon the very existence of these forest areas, the soil on the hill sides was exposed to the fury of the natural elements. The silent sentinel that mount guard over the mother earth were dismissed and the inevitable result followed. With the rains, the soil from the hills was washed down to the plains and thence to the sea Cities which were known to be sea ports are now well inland. To take an example nearer home, the spectacular case of the Punjab Siwaliks fringing Himalayas, tells a sorry tale. Owing to excessive grazing and the repeated firing of the vegetation and hacking of trees by the herdsmen, whole faces of the hills which only a few decades ago were well wooded, now present a sorry spectacle of barren and badly eroded slopes, threatening the plains below. The once perennial streams have dried up, the once well-defined streams

were let loose to follow whichever course they liked, the heavy rains — emboldened by the removal of the 'guards' that used to protect the soil—attacked the exposed surface with all their fury, and finally the floods of liquid mud issued into the plains and as the velocity of the water decreased, silt and mud get deposited to form detrital cones. These cones got gradually extended and rendered the cultivable lands unfit for any use. Fortunately for this portion of the country, the forest department stepped in and stemmed the wave of destruction and land is being reclaimed.

Instances are not wanting still nearer home in our country, *i. e.*, in the southern parts of the country. The sandy stretches of the Hagari river and the 'Theris' of Tinnevelly district and the cleared outer slopes of the Nilgiris are formidable examples of how man misbehaved and disturbed the balance so laboriously brought into existence by Nature, by his thoughtless and highly selfish actions. From these it can readily be seen that soil erosion in its very severe forms is a man-made phenomenon affecting the lives of thousands of human beings in that their lands are laid bare.

Soil erosion thus is not a problem of modern times only. It is there even from pre-historic times since man first turned the top soil to grow his food. But the evil effects of this process which were accelerated by the defective methods employed by man in the past for exploiting natural resources have become so pronounced of late, that soil erosion is receiving world-wide attention today.

Soil-erosion in peninsular India has not assumed such serious proportions as in the northern portions of the country, thanks to the existence of very old geological formations as a land area, the palaeozoic era and since the soils derived from the weathering of granitic and gneissic bed rock are very stable. Further, the development here has been slower as the major invasions have taken place from the north. As a result, the denudation of the uplands here has not progressed to the same extent. A sound policy of reservation has saved appreciable areas of hill forests. Despite the formidable structure of the rock formation and the resulting soil standing as a challenge to the forces of soil erosion, man either in his folly

or selfishness, has suceeded at places in disturbing that beautiful natural balance wherein soil erosion has been kept in check and is allowed to proceed only in a natural and undisturbed enviroment. Man entered the scene with his axe, removed the vegetation, put the land under cultivation, disturbed the natural balance existing between the soil, its vegetational cover and climate and thus helped the removal of the surface soil at such a fast rate that it can never be built up by the soil forming processes. Erosion is thus accelerated. How the cover of vegetation helps to retard the progress of soil erosion can be easily understood, if we consider the case of a single drop of rain. When it strikes on the land covered with a thick blanket of vegetation, it breaks into a spray of clear water which slowly finds its way in the form of numerous channels into the soil, but when the same thing happens on bare soils, due to the force of impact, a drop of muddy water is created. This muddy drop is not allowed to sink into the soil due to a thin film of fine particles of silt filtering out and arresting the process. This film chokes the pores of the soil. The result is that only a small portion of the water percolates into the soil. The other parts flow downhill into streams carrying with them a load of soil. This being the case of a single drop of rain, we get a full picture of the effect of a full rain, by multiplying this single drop several billion times. We then get a picture of the flow of a filmy soil-charged water along the surface. As the volume of water increases, the velocity gets accelerated and water acquires more erosive power. It was proved in the United States of America that floods have increased in the country in frequency, volume and velocity during the past 40 years and this is primarily due to removal of vegetative cover by overgrazing and deforestation which resulted in accelerated run off. The forms of erosion by water, viz., sheet erosion and gully erosion are too well known to merit any detailed description. Sheet erosion when neglected usually ends in gully erosion. The productive capacity of a land gets diminished due to continuous erosion and the consequent loss of its fertility.

It would be interesting to trace here the growth of a particular type of cultivation of the hills known as shifting cultivation which is a forerunner of eroded soil formations.

With the Aryan occupation of the better cultivable lands of India in the plains, the aboriginees were forced into the hills where they practiced cultivation of crops on the hill sides. The soil under the hill forests was excellent and with the minimum trouble by ways of felling the tree growth, burnig it, it was found possible to raise a good crop, by just scratching the ground and sowing the seed. However after years of such a wasteful cultivation, the yields began to diminish and the cultivator was forced to seek for new places of virgin forest-land to start his operations afresh. This method of hopping from place to place for purposes of cultivation came to be known as shifting cultivation, the local names of it being, PONAM and KUMRI in some places, and PODU in the Agency areas of the Andhra districts. After abandonment of land by the cultivator, an inferior forest growth appears thereon, which restores the fertility of the soil to an extent, but no sooner this happens then a repetition of the whole process of cultivation sets in thus reversing the process of rehabilitation and reclamation attempted by nature. These processes get repeated till such time as the land becomes totally incapable of holding either cultivation or forest growth. This leaves the soil in such a state of total exhaustion and usually the ground is a shallow skin of poor earth over bed rock which will take centuries to recover even under the most favourable treatment. Owing to such methods adopted over centuries, thousands of acres of excellent forest lands have been reduced to mere scrub jungle. The consequences of allowing this to continue are serious, as it results in loss of national wealth. Therefore the areas supporting forest were converted into reserved areas where shifting cultivation was totally banned and in some other areas, where this could not be done, a method of reclothing the devastated areas by a forest crop, known locally by different names such as KUMRI, TAUNGYA, was developed whereby side by side with agricultural crops a forest crop is also raised, the latter occupying the land as the cultivator abandons it.

The PODU cultivation practiced by the hill tribes of the Agency areas of the Andhra State has no doubt a deleterious effect on the soil. These hill tribes eke out a precarious existence by adopting most primitive agricultural practices. These Agency tracts form

parts of the districts of West Godavary, East Gadavary, Visakhapatnam and Srikakulam. The forest area in these tracts is nearly 5,500 square miles in extent out of which nearly 2,300 sq. miles are either reserved forest, reserved land or special unreserves and no sort of cultivation is allowed therein. The rest are ordinary unreserves. They are also as thickly wooded as the other areas, but are being destroyed at a rapid pace by the destructive method of cultivation. If this soil rape is allowed to continue longer, most of the unreserves will ultimately become fit only for quarrying.

The entire agency is populated mostly by the scheduled tribes of different castes and creeds with a few plainsmen who have settled down mainly for agriculture and trade purposes.

There are two forms of PODU cultivation that are practiced by these hill tribes. One is called the ordinary or CHILAKA PODU and the other hill or KONDA PODU. The former is on flat ground and is cultivated for several years while the latter is on the hill slopes and is generally abandoned after one or two crops are taken off the land. In February or March the land is clearfelled and the debris burnt during March or April after spreading it evenly on the ground. The ashes are to act as manure. One or two ploughings are done in CHILAKA PODU but no ploughings are done in KONDA PODU. Seeds of hill CHOLAM and SAMAI are sown with the rains and whatever is available is harvested. KONDA PODU is generally practiced on steep hill slopes, often too steep to hold either moisture or soil. As the fertility of the field gets rapidly exhausted, the hill people are compelled to resort to new places of activity. The luxuriant forest, which a bountiful Nature has created, affords a vast source of activity for these people in this direction. The fertility built into the soil by a patient Nature over several decades is readily laid to waste in a matter of one or two years by the thoughtless human being. The cultivator keeps on moving from place to place in this fashion leaving behind in his trail ghastly patches of land with badly hacked, charred and lopped trees dotted here and there. Large areas of forests have already been clearfelled and devastated in this way and the injurious effect of

such large scale clearance on the climate and rainfall of the country can easily be understood and this question cannot be brushed aside to be considered leisurely at a later date. During 1949, the provincial Government has appointed a committee of experts belonging to the different departments of the State to draw up proposals as to how best to develop these agency areas. A forest expert was also attached to the committee. He has prepared an elaborate report on the 'Improvement of Forests and Amelioration of the Hill Tribes'. Among other things, the forest expert discussed this important aspect of land management viz., PODU cultivation. While discussing the evil effects of Podu cultivation on soil conservation, he has observed that although soil erosion has not yet assumed alarming proportions in these agencies, still the evil effects, such as silting of tanks, drying up of once perenniel streams and rivers, lowering of water level in the wells are noticeable here and there. It was also admitted that PODU has to be permitted until such time as suitable lands can be found for permanent cultivation for the increasing population, as these hillmen have no other lands for cultivation. The following restrictions were sought to be imposed on the cultivators.

(1) that no land within five chains of Reserve Forest or a special unreserve or any protected block be cleared for PODU,

(2) that no land used for Podu once, be cultivated again before ten years after abandoned,

(3) that trees felled in podu be properly coppiced,

(4) that no land within two chains of a stream bank be cleared for PODU except for raising fruit gardens,

(5) that no clearance be made on slopes higher than one-third of the hill slope from ground level,

(6) that certain important timber trees like teak, yegisi (Pterocarpus marsupium), Maddi (T. tomentosa) of above 4 ft. in girth at breast height which may be

felled while clearing the land be properly stacked at the edge of PODU and handed over to the forest department,

(7) that not more than five acres of land be used for PODU at a time by a single family,

(8) that lands used for PODU shall be continuous unless interrupted by uncultivable land,

(9) that blocks of land wherein PODU cultivation is to be allowed be permanently demarcated by a cleared line and to lease out the other available lands for coffee cultivation,

(10) that bamboos should be raised on the abandoned PODU lands to serve the double purpose of affording cheap poor man's timber to the villagers and to help prevent soil erosion in conjunction with the coppice growth from the stumps in the podu,

(11) that the hillmen be colonized on suitable areas and be made to take to settled cultivation and to afford irrigational facilities (a scheme involving large scale disreservation of forest areas).

It was also felt by the forest expert that attempts to prohibit PODU should not be made as it was found from past experience that such a measure resulted in the dwindling of the population.

It was however felt by some other forest officers that all these rules except rule 8 above have been in existence in one form or the other for the past fifty years or more and have been disregarded with impunity by these hillmen for the simple reason that enforcement was impracticable. It was even felt by them that the proposal to allot five acres of unreserved land for each hill family (item 7 above) is rather excessive, for, about 301 sq. miles of unreserve will have to be reserved for this soil rape. They argue that in a thickly populated country like ours, it is inequitable that

so much damage of soil resources should be permitted for the benefit of so few. They are firm in their belief that unless PODU is prohibited altogether, the inevitable result must follow. They feel that even the hillman is not very enthusiastic about the podu. He takes to it in the absence of any other alternative. Podu according to them does not bring a return commensurate with the work involved. It was suggested by them that five years time should be allowed to stop Podu, during which period intensive propaganda should be done against podu, teach the hill men better methods of cultivation, manure preservation etc., and render technical assistance to them for carrying out repairs to their irrigation works etc. It was also felt by them that however laudable the idea of the colonization scheme (item 11 above) there is an objection to this from the forest point of view. That is, large scale disreservation such as this, go against the very interests of the persons on whom the benefits are sought to be conferred. Disreservation and the consequent deforestation will lead to drying up of perennial springs and loss of the very soil so essential for the development of agriculture. The intrinsic right of the forests to a permanent and adequate share of the land has been well recognized and forests are no longer to be treated on sufferance, until better use can be found for the land they occupy. A solution of the successful colonization of the hillmen lies in the intensive aspect and not in the extensive aspect of the problem. It is better to take up first of all the colonization in the unreserves and waste lands, watch the results and if and when the available lands are exhausted, then the question of disreserving areas may be considered.

It is however a generally recognized fact that all our endeavours should be to promote the well-being of the hillmen, to make them more civilized. Unless we want to keep them in a state of perpetual backwardness, it is our imperative duty to make them realize their mistakes and tread the path of recognized civilization.

As is pertinently realized, however, the need of the hour is to carry conviction by demonstration, examples and precept. In these backward areas, conversion and not coercion should be the watchword. The immediate problem facing the forest officer is the quick rehabilitation of the abandoned podu lands especially on the steep

slopes before serious damage sets in. Even if KONDA PODU cannot be prohibited immediately, it should be canalised in right directions. The areas have to be rehabilitated in as short a time as possible, by reclothing the areas with a suitable forest crop. A species has been found — its only limitation being the high altitude of about 3 000 to 4 000 feet it requires for healthy development — which would fulfil most of the preposterous conditions that a regeneration of these areas would impose. It is wattle (Acacia mollissima). It is easy to propagate, ready to fell in eight or ten years, builds up fertility in the soil (being a leguminous species,) its wood can be burnt, and its bark is of such high economic importance as a tanning material, that if successfully grown, it is capable of revolutionizing the whole economic structure of these backward areas. A start has been made to reclothe suitable areas with this species, and it is hoped that experiments that have been started will yield such hopeful results that once again as in the case of the Punjab Siwaliks, the Forest Department can well take pride in having rendered a magnificient service to the nation by rehabilitating lands that have not only been rendered unproductive by themselves but have become sources of potential danger to the adjoining cultivable lands.

Thus a movement has been set afoot to regulate the Podu cultivation which has been recognized to have evil effects on the soil structure. It is the duty of every citizen to lend support to whatever measures the Government might take in this direction. It would be the easiest thing to criticise the Government saying that they are unnecessarily harsh on innocent hillmen, but who can deny that it is of paramount importance to guard the interests of posterity, when a neglect of such interests will vitally effect their very existence.

Before it is too late.

by **Iyppu, (Silviculturist, Travancore-Cochin State).**

"Trees, shrubs and plants are the earth's raiments" wrote Jean Jacques Rousseau in one of his "Promenades". This garment has been rent and vast areas of the Travancore-Cochin State forests have been robbed of its protective forests. The acute shortage of food and increasing number of population necessitated the lavish sacrifice of the forests of the State. The Grow More Food Campaign which had to be generously encouraged by Government coupled with acute land hunger made the rich forests of the State an easy victim of exploitation. Erosion became a hundredfold active in the newly opened out areas which are cultivated. The devastation of forests had such a grave and pointed consequence that the Travancore-Cochin State has to take resort to the Travancore-Cochin Land Development Act XXXVI of 1950 which envisages the necessity for the preparation and execution of Schemes for the control and prevention of Soil erosion. Preservation of the fertility of the land is a vital and crucial problem which cannot be neglected any further.

2. Most of the forest areas that have been brought under the plough, are blessed with an annual rainfall of about 200″ and with a soil which is deep and fertile.

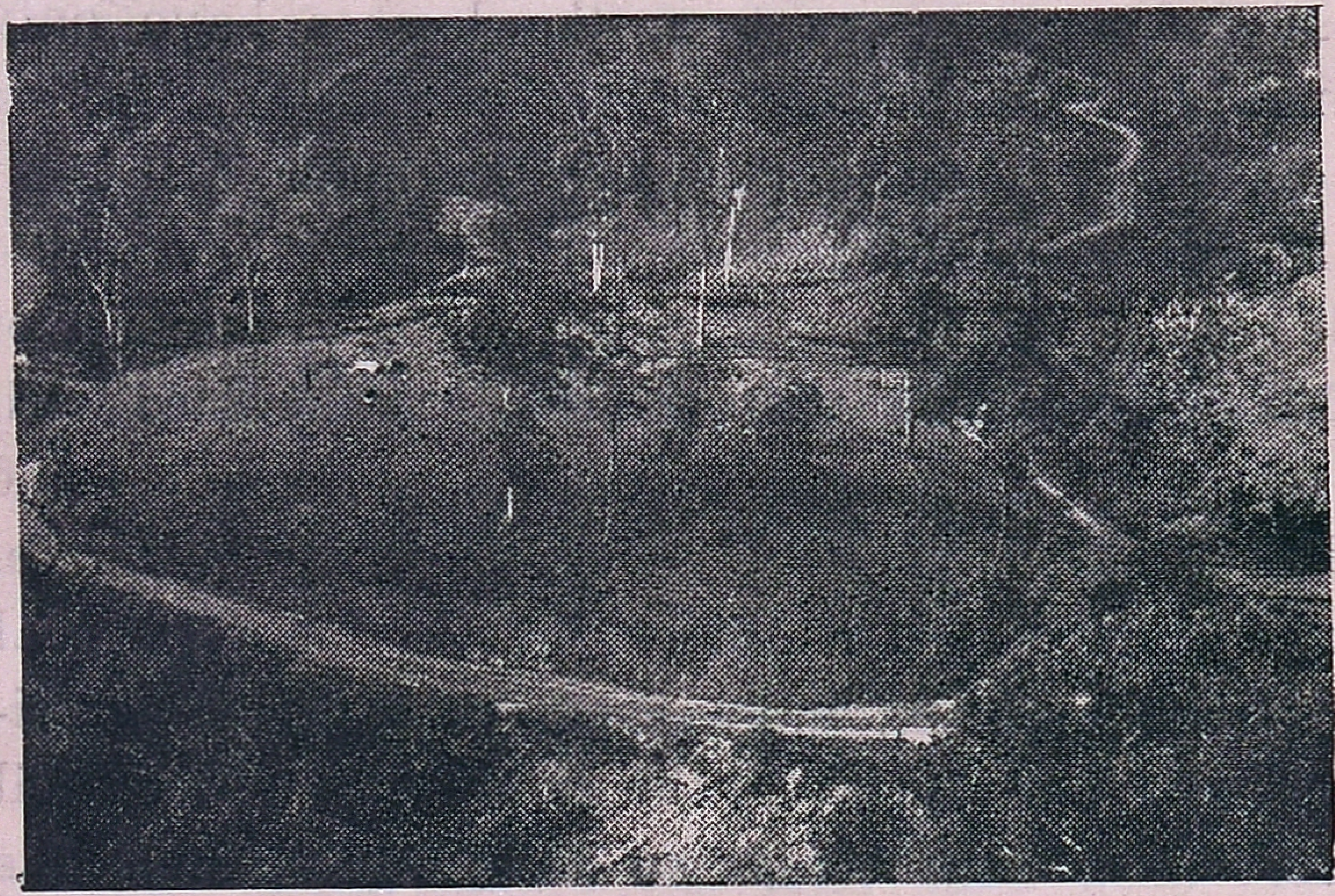
3. Though the heavy rainfall and rich loamy soil are beneficial in nature usually, when menaced with over exploitation with the help of axe and fire for purpose of cultivation, turned out to be accelerating factors of erosion. Extensive deforestation has lowered the water table by destroying the vegetative cover which holds water on the slopes and forces it to penetrate into the soil. Run-off and silting have progressed to such an extent that it has become a threat to the catchment areas for the two important rivers of the State, the Periyar and the Muthirapuzha on which are built the huge Hydro-electric Projects, the Pallivasal and the Sengulam schemes and on which two

more projects are proposed to be constructed. If the present intensity of erosion is not checked, the future of these Schemes may be in danger.

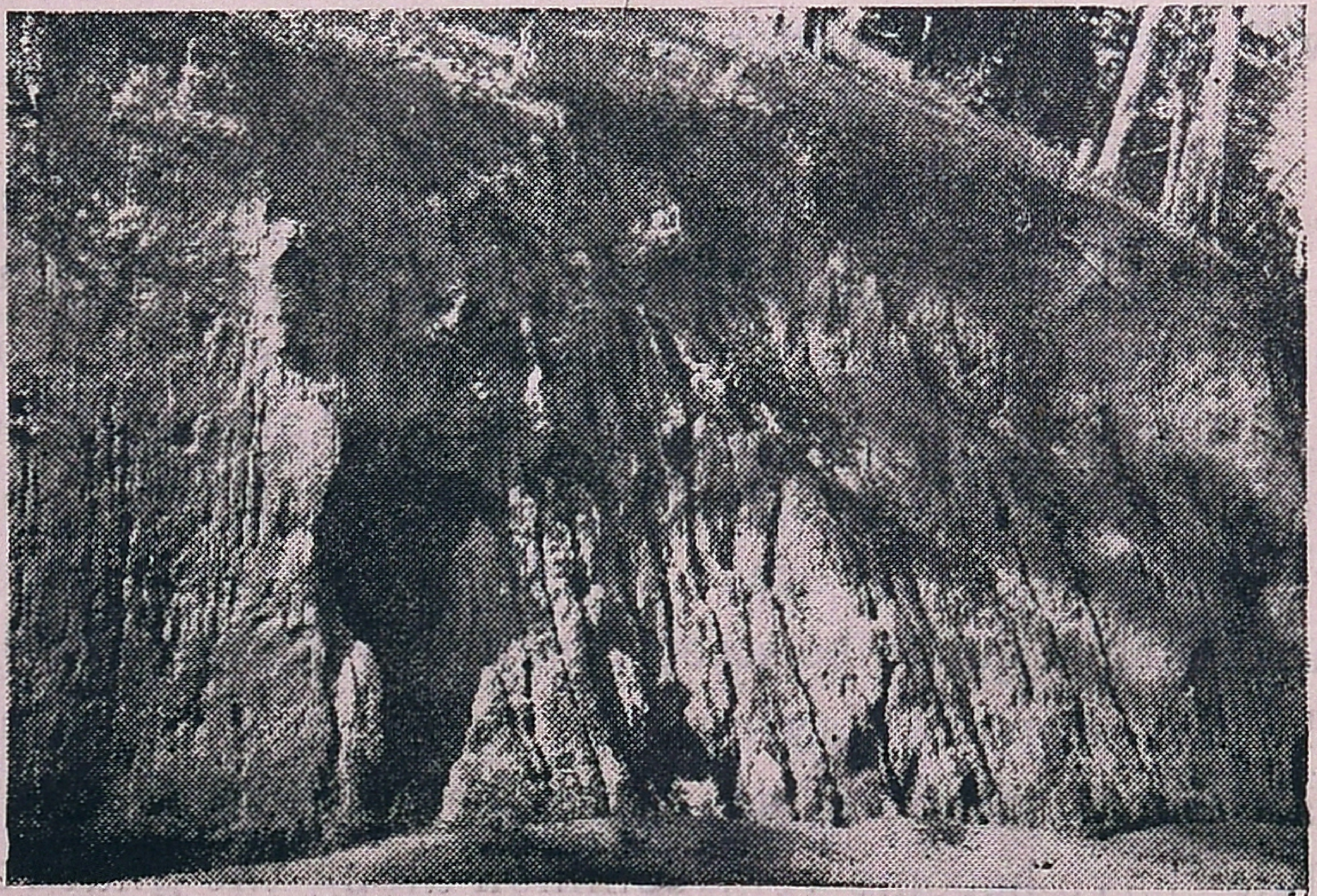
4. The history of soil erosion is the history of the use and mis-use of agriculture. During the world war II when food scarcity began to be felt very keenly, lots of forest land were opened out for cultivation under the Grow More Food Campaign. Not much consideration was bestowed on the advisability of clearing up certain forest areas, and the local ryots adopted their local up-country methods of cultivation which resulted in serious soil erosion and loss of productivity of soil. The leases being mostly of temporary nature, the lessees have only tried to take the maximum advantage with the minimum effort on their part, and naturally they did not pay much attention to the future, for the protection of soil or to the topography of the country. The whole operation was solely guided by the slogan of "Cash and Carry". Most of the area was originally cultivated with paddy, but as the fertility of the land decreased, tapioca took the place of paddy which is a comparatively costly crop to cultivate, and the increase in the demand for tapioca, has given a general impetus to the local ryots to bring more area under tapioca cultivation which is the most harmful from the point of view of soil erosion. But the time is not far off when this land which has now lost most of its fertility will not be even suitable for tapioca and will have to be abandoned.

5. The after effects of the last few years of careless cultivation are clearly seen from the heavy silting up of streams, in the increasing number of floods and the loss in yield. Either banks of the rivers and their tributaries have been cleared and even levelled to a considerable extent for cultivation, thereby plugging up the rivers at their very source. Vast areas which once retained excellent forests have now turned out to be steep practically barren slopes where gully and sheet erosion are playing their part in a most disastrous way. The cardamom plantations have begun to dwindle in acreage. Landslides have become very common along the ghat-roads.

6. While practicable means and methods suitable for varying conditions of soil and site are to be evolved to check and stop soil erosion, it is highly necessary to study the details and collect basic data about soil erosion from various important centres. More systematic and serious steps are to be taken to maintain the fertililty of soil, to arrest the spread of eroded soil on fertile low-lying land, to minimise the number and intensity of floods, to protect the roads and bridges, to prevent the silting of streams and rivers, the check the fall of water table and to safeguard the costly Hydro-electric projects. Let the works of soil erosion be given the priority it deserves before it is too late.

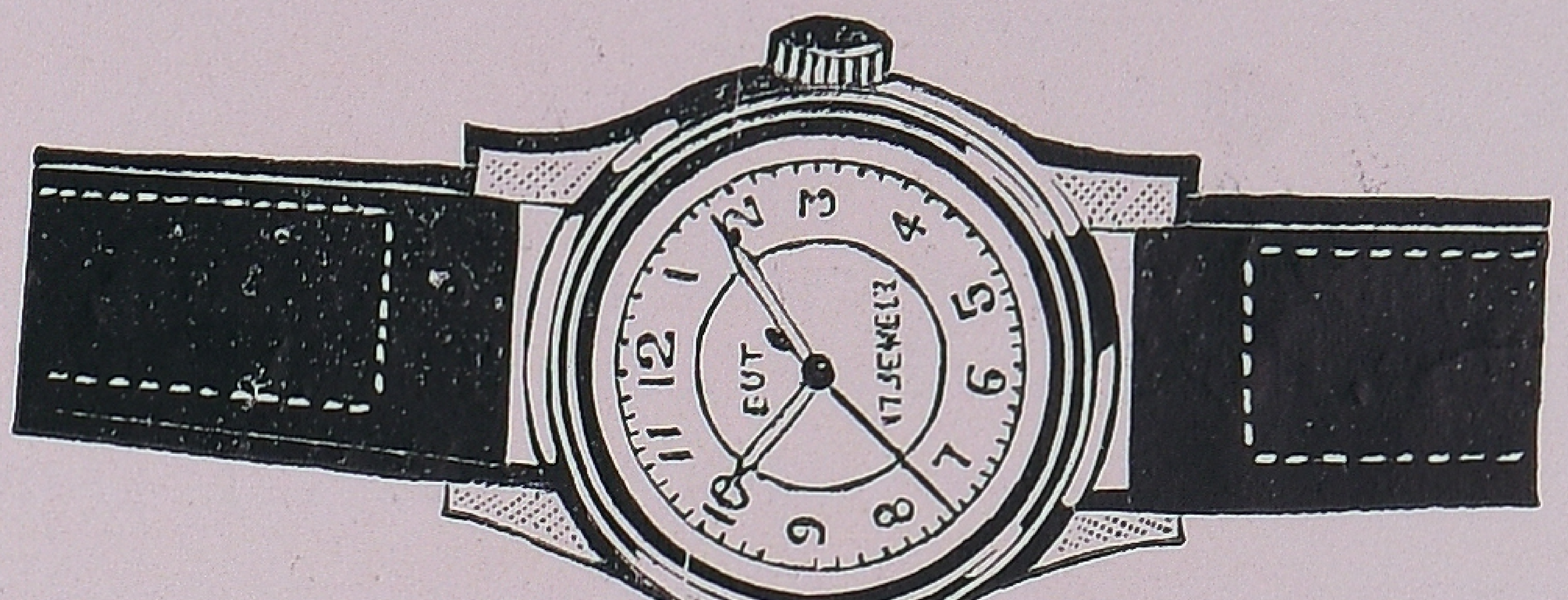


Where will this end?



Stage of Erosion.

Photos by:
Sri A. I. Iyppu.



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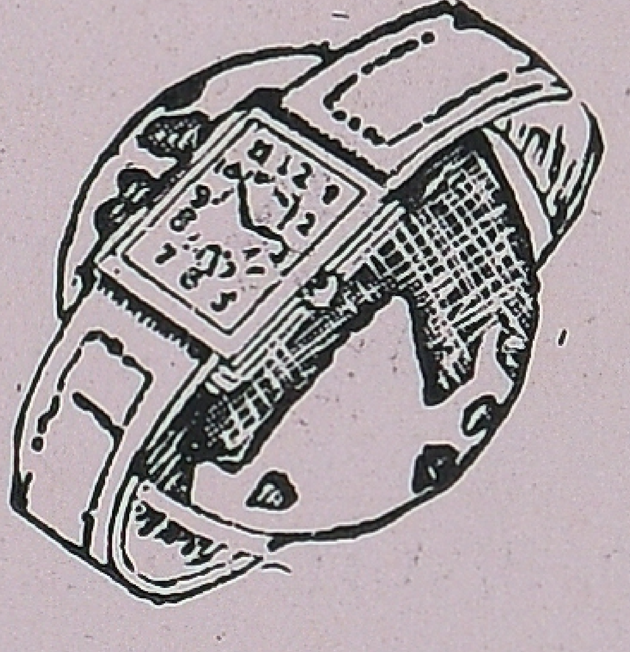

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